ASPECTS *OF* MINERALIZATION IN THE SKIN OF TEE GOAT CAPRA HIRCUS (L) OF ZARIA, NIGERIA.

BY

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D E D I C A T I O N

This dissertation is dedicated to my God and Lord Jesus Christ whose grace has enabled me to complete this work ;

and to

my dearly beloved wife and mother of my children, Florence Ngozi Agina, whose encouragement and love have cheered me up through the many months of labour to complete the work.

D E C L A R A T I O N

I declare that this Thesis, as herein submitted, is the document of my research work carried out in the Ahmadu Bello University under the supervision of Dr. J.O.D. Adegboye who is the head of the Department of Biological Sciences, Ahmadu Bello University, Zaria. This Thesis has not been submitted in any form for another degree, diploma or other certificates at any University, or Institution. Information derived from the published and unpublished work of others has been duely acknowledged in the text.

Aginable

AGINA, M.I.

A C K N O W L E D G E M E N T S

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A B S T R A C T

The composition and distribution of mineral elements in the skin of goat (Capra hircus Linneus) from the Zaria zone of the Guinea Savannah region of Nigeria were investigated. Nine physiologically important elements were detected. The mean moisture content was found to be 63.47%, the total Ash was 1.71% and the organic matter was 34.82%, of the wet (fresh) weight of the skin. On dry weight basis the Ash was 4.68% while the organic matter was 95.32%. The mineral ash contained 0.05% Calcium, 0.15% Sodium, 0.09% Potassium, 0.02% Magnesium, 0.02% Zinc, 0.07% Iron, 0.01 % Copper, 0.03% Nickel and 0.01 % Cobalt. There were significant differences in the concentration of the elements in the different regions of the skin, namely:- the neck, the chest, the anterior shank, the belly, the mammary area, the posterior shank, the front butt, the butt, the back-bone and the tail regions. Computations showed that zinc was negatively correlated with copper and the relationship was significant at $P < 0.05$. The other ions in the skin were significantly related directly to each other. The physiological implications of these relationships and other findings were discussed. A distribution map of the investigated elements for the goat skin was produced.

TABLE OF CONTENTS

		PAGE
DEDICATION		ii
DECLARATION		iii
ACKNOWLEDEMENTS		iv
ABSTRACT		vii
LIST OF TABLES		xii
LIST OF FIGURES		xiv
LIST OF PLATES		xvi
ABBREVIATIONS AND SYMBOLS		xvii
GLOSSARY		xix
CHAPTER ONE :	INTRODUCTION	1
1.1.0.	Subject of Study.	1
1.2.0.	Justification	1
1.3.0.	History of the problem	2
1.4.0.	Statement of the research problem	5
1.5.0.	Research method	5
1.6.0.	Data collection	6
CHAPTER TWO :	LITERATURE REVIEW	16
2.1.0.	The Skin	16
2.1.1	Definition	16
2.1.2	Structure	16
2.1.3	Biological function	22
2.1.4.	Skins as raw material for leather manufacture	25
2.2.0.	The Goat	29
2.2.1.	Classification	29
2.2.2.	Hair distribution on the	

PAGE

goat skin 32

2.2.3. Distribution and feeding habits. 33

2.2.4. Geographical factors which probably affect the distribution and mineral ion status of the Guinea Savannah goat . . . 36

2.3.0. Bioelements. 43

2.3.1 General 43

2.3.2. Zinc 45

2.3.3. Copper 48

2.3.4. Iron. 53

2.3.5. Cobalt 55

2.3.6. Nickel 57

2.3.7. Magnesium 57

2.3.8. Calcium 59

2.3.9. Sodium 61

2.3.10. Potassium 62

2.4.0. The Research Area 63

CHAPTER THREE : MATERIALS AND METHOD 66

3.1.0. Collection of Specimen 66

3.2.0. Procedure 66

3.2.1. Physical measurements . . 66

3.2.2. Determination of moisture content 67

3.2.3. Determination of ash content .. 68

3.2.4. Determination of organic

PAGE

content 69

3.2.5. Determination of mineral ion content 69

CHAPTER FOUR : RESULTS AND OBSERVATIONS . . . 77

4.1.0. Physical parameters 77

4.2.0. Relationships between some physical values obtained for the goats . . . 77

4.2.1 Live body weight vs. Total length 77

4.2.2. Body weight vs. wet weight of whole skin 80

4.2.3. Other physical values . . 80

4.3.0 Moisture content 83

4.4.0. Ash and organic matter 84

4.5.0 The mineral elements 93

4.5.1. Mineral ion content (composition) 93

4.5.2. Distribution of the mineral elements 101

4.5.3. Inter-relationships and correlation 102

CHAPTER FIVE : DISCUSSION 131

5.1.0. General 131

5.2.0. Physical relationships 132

5.2.1. Relationship between body weight of the goat and it's total length 132

5.2.2. Body Weight versus wet weight of whole skin 133

5.2.3 Other physical relationships . 133

PAGE

5.3.0. The moisture content of the goat skin 134

5.4.0. The Ash content and the Organic matter content of the goat skin . . . 138

5.5.0. The mineral element composition of the goat skin . . . . . .

5.6.0. Distribution of the mineral elements in the goat skin 147

5.7.0. The inter-relationships between the metal ions; and between the metal ions and other measures 149

5.8.0. Evaluation of the nutritional quality of the goat skin in terms of the mineral element composition . . . 151

5.9.0. The hair of goat skins as feed supplement 155

SUMMARY 159

CONCLUSION 162

REFERENCES 163

APPENDIX

I Table 4.4a. 174

II Table 4.4b. 175

III Table 4.4c. 176

IV Table 4.4d. 177

LIST OF TABLES

TABLE NO.		PAGE
2.1	Livestock population count in Gongola State of Nigeria (1982)	35
2.2	Concentrations of copper in whole body of various species	50
4.1.	Values of physical measurements made for ten goats, Capra hircus (Linneus)..	78
4.2.	Values of live weight and total length for ten goats	81
4.3.	Values of body weight of the goats and the weights of fresh whole goat skins..	82
4.5.	Mean values of moisture content for ten different samples taken from each of ten different goat skins numbered 1 - 10 ..	87
4.6.	Average moisture content for different regions of the goat skin	88
4.7.	Values for ash content of goat skins ..	89
4.8.	Values for organic content of goat skins.	90
4.9.	Ash content of various portions of the goat skins	91
4.10.	Organic content of various portions of the goat skin	92
4.11.	Ash and Mineral ion content of 100 g fresh goat skin	95
4.12.	Computed values for ash and mineral ion content of goat skin based on wet weight of whole skin	97
4.13.	Total mean weight of mineral ions detected in 10.00 g skin samples from various regions of the goat .....,	98
4.14a.	Ash and Mineral ion content of 100 g fresh goat skin taken from different regions of the animal (values were calculated from mean of ten values each)	99

TABLE NO.		PAGE
4.14b.	Ash and Mineral ion content of 100g fresh goat skin taken from different regions of the animal (values were calculated from individual original values and not means)	100
4.15.	Correlation coefficients between pairs of mineral elements in the goat skin ..	104
5.1.	Grain layer thickness and hair numbers of different regions of the goat skin .	136
5.2.	Mean values of the mineral elements present in the Guinea Savannah goat skin	145
5.3.	Comparison of values of mineral ion content of the Guinea Savannah goat skin with typical values obtained by various workers and reviewed by Rothman (1954).	146

LIST OF FIGURES

FIGURE NO.		PAGE
1.	Trarsverse section of the goat skin ...	18
2.	Structural layers of the goat skin ...	20
3.	Flayed goat skin	24
4.	Vegetation zones of Nigeria (Map) ...	37
5a.	Relationship between live body weight and total length of goat	79
5.	Relationship between body weight and wet weight of whole skin of the goat ...	85
6.	Relationship between the total length and the wet weight of whole skin of the goat	86
7.	Calibration curve for Calcium ...	107
8.	Calibration curve for Potassium ...	108
9.	Calibration curve for Zinc	109
10.	Calibration curve for Copper ...	110
11.	Calibration curve for Nickel ...	111
12.	Calibration curve for Cobalt ...	112
13.	Calcium concentration in different regions of the goat skin	113
14.	Sodium concentration in different regions of the goat skin	114
15.	Potassium concentration in different regions of the goat skin	115
16.	Magnesium concentration in different regions of the goat skin	116
17.	Zinc concentration in different regions of the goat skin	117
18.	Iron concentration in different regions of the goat skin	118
19.	Copper concentration in different regions of the goat skin	119

FIGURE NO.		PAGE
20.	Nickel concentration in different regions of the goat skin	120
21.	Cobalt concentration in different regions of the goat skin	121
22.	Relationship between the mineral ion content and total length of goat ...	122
23.	Relationship between moisture and zinc levels in fresh goat skin	123
24.	Relationship between zinc and copper ions in the goat skin	124
25.	Relationship between Potassium and Magnesium ions in the goat skin	125
26.	Relationship between Sodium and Magnesium ions in the fresh goat skin	126
27.	Relationship between Zinc and Magnesium ions in the fresh goat skin	127
28.	Relationship between Zinc and Magnesium ions in the goat skin	128
29.	Relationship between Zinc and Sodium ions in the goat skin	129
30.	The distribution Map of Mineral Elements in the goat skin	130

LIST OF PLATES

PLATE NO.		PAGE
I.	Typical Guinea Savannah goats	8
II.	Collection of goats from different local government areas of Zaria	8
III.	The dwarf black goat of Southern Nigeria mating a Guinea Savannah brown goat.	9
IV.	Goats feeding on rubbish heaps	9
V.	Goats feed on a wide variety of food materials	10
VI.	The Guinea Savannah pasture lands	10
VII.	Open Savannah woodland with tussocky grasses, shrubs and trees....	11
VIII.	Skins being roasted over fire	11
IX.	Chunks of roast skins in heaps for sale.	12
X.	Business in roast skins	12
XI.	Commercializing skins	13
XII.	Skins for home consumption	13
XIII.	Dried goat skin (flesh side) with punches indicated by investigator	14
XIV.	Dried goat skin (grain or hair side) held by investigator showing sites from which samples were taken for analyses.	14
XV.	Cork borer used for making punches in the goat skins	15
XVI.	Hansen - 125 Scale used for weighing (by substitution) all the goats used during the investigation	15

ABBREVIATIONS AND SYMBOLS.

Throughout this written work only standard abbreviations and symbols were used. These are as listed below :-

Ca	Calcium
Na	Sodium
K	Potassium
Mg	Magnesium
Zn	Zinc
Fe	Iron
Cu	Copper
Ni	Nickel
Co	Cobalt
Hcl	Hydrochloric Acid
H_2SO_4	Sulphuric Acid
HNO_3	Nitric Acid
Conc.	concentrated
Cont.	continued
nm	nanometre
mg	milligram, milligramme
kg	kilogram, kilogramme
m	metre
l	litre, 1000 cubic centimetres
cm	centimetre
mm	millimetre
ml	millilitre, 1 cubic centimetre
p.p.m.	parts per million
g	gram, gramme
%	percentum - used interchangeable with percent.

^{o}C	degree centigrade
S.E.	Standard Error
yr(s)	year(s)
vs.	versus
r, R	Coeficient of correlation; both are used interchangeably.
Org.	Organic
L.	Linneus
A.A.S.	Atomic Absorption Spectrophotometer
I.L.C.A.	International Livestock Centre for Africa.
>	greater than
<	Less than
P	probability
Fig.	Figure
( )	parenthesis indicates important statements.
Σ	(sigma) Sum
/	per
F.A.O.	Food and Agricultural Organisation of the United Nations.
S.L.C.	Society of Leather Trades Chemists
S.A.C.	Society of Analytical Chemists
A.O.A.C.	Association of Official Analytical Chemists.

G L O S S A R Y

1. 'Hides and Skins' are terms used conventionally in the Leather Industry to distinguish between the skins of large and small animals. The term 'Hides' stands for the skins of large animals such as cow, horse, hippopotamus etc. while the term 'Skins' stands for the outer covering of smaller animals such as goats, sheep, snakes.

2. 'Tanning' is a word used for describing the processing of perishable raw hides and skins by the use of substances called tannins, or synthetic chemicals, into the permanent and imputrescible form of leather.

3. 'Leather' - this is a general term for hide or skin with it's original fibrous structure more or less intact, tanned to be imputrescible. The hair or wool of the skin may not have been removed.

4. The term 'raw hide' is used in this work to represent a hide which has only been treated to preserve it prior to tanning.

5. The term 'wet skin' is used interchangeably with the term 'fresh skin'. They describe the freshly flayed skin before they are dried.

6. 'Grain' - Pattern, characterized by pores and peculiar to the animal concerned, visible on the outer surface of a hide or skin after hair or wool has been removed.

7. 'Beam house' as used in the text represents the entire process of preparing raw hides and skins for final tannage. These processes are usually carried out in a section of the Tannery referred to as 'Beam house'.

8. Fecundity' - fertility, ability to reproduce rapidly.

I N T R O D U C T I O N

SUBJECT OF STUDY

This study is geared towards estimating and evaluating the mineral elements (metal ions) of typical goat skins from the Northern Guinea Savannah region of Nigeria. It is intended to survey the distribution of physiologically important mineral elements in the goatskin and hence to establish their abundance in relation to the area of the skin where these elements may readily be found. The physiological status of the skins may then be evaluated in terms of their mineral ion content.

JUSTIFICATION

Generally, data on the mineral element composition of goats are very scanty and non-existent for the skin of Nigerian goats. Hides and skins which form part of the diet of many Nigerians (see plate XII) have been classed as being of no real nutritional value since, it is argued, the skin proteins - mainly collagen, elastin and keratin (from the hair) - are not really available to man through the normal digestive processes. If the above statement is valid, then the edible portion of the skin needs to be analysed for any other constituents that may have some nutritional value. Particularly the mineral elements.

Hides and skins are the raw materials for the Leather Industry. If the food value of these materials, even in terms of mineral element content, can be proved to be unimportant, then the Leather Industrialist would have scored a point in his campaign against the use of hides and skins for food.

In leather Science it is known that the quality of any given leather depends partly on the properties of the raw skin and partly on the process of manufacture. O'Flaherty, et al, (1956) confirmed this fact by stating that a recognition of the existence, nature, and significance of the properties of the raw stock is of great importance in a scientifically controlled tannery process. It is known, too, that metal ions, eg. Copper ions, interact with collagen to produce changes in the chemical and physical properties of collagen which constitutes the major component of hides, skins or leathers. (Rucker, et al, 1969).

Since the mineral elements are structural as well as physiological features of the hides and skins, any investigation of the quality of these raw materials of the Leather Industry must of necessity include studies on the minerals. Hence this study is concerned with the composition and distribution of mineral elements in the skin of the Nigerian goat, Capra hircus (Linneus).

HISTORY OF THE PROBLEM

Generally, it has become widely accepted in the Leather Industry that the skins of a breed of goats from the Sudan zone of Northern Nigeria (Sokoto area, namely) yields high quality leathers on tannage (Devendra and Burns, 1970). It's Leather is to be preferred to leathers made from skins of goats from other regions of Nigeria. This breed of goats is morphologically similar, in all respects, to the goats of the Guinea Savannah region (Plates I and II) except that the

hair and skin colour is of a deeper red than that of the goat of the Guinea Savannah whose colour is usually light or dark brown. As a sign of their fame the Sokoto goats are simply referred to as "Sokoto reds". Tanners normally pay higher prices for the Sokoto red goat skins than for the skins of goats of other breeds in Nigeria.

The quality of leather, however, is judged on its suitability for the purpose for which it was made. Thus, leather produced for the manufacture of shoe soles, for instance, must have high tensile strenth and resilience in order to resist tear and wear. Therefore the quality of the constituent proteins of the raw material becomes important.

From the findings of Rucker, et al, (1969) that copper ions form cross-linkages with collagen fibres and that such cross-links make for increased tensile strength in the entire net-work of the fibres, it is logical to infer that a tissue made up largely of collagen, such as the skin, will have low tensile strength when devoid of copper ions and a higher tensile strength when these ions are present. Thus, leather produced from a copper-deficient skin for the manufacture of shoe soles will certainly be inferior to one prepared from a non-copper deficient skin for the same purpose. It does not seem, however, that the quality control expert in the Leather Industry has seriously considered the possibility that the quantity and distribution of mineral elements in the skin may have some profound effects on the quality of the finished leather.

In Nigeria, apart from their use for the manufacture of leather, goat skins are used for food. They are either eaten together with the flesh part of the animal as in most Southern States after the hair has been removed, or the animal is flayed and the skin hair burnt off over a flame (plates VIII and IX) and skin cooked. The de-haired skins are highly commercialized locally. They are cut up into large chunks and sold in small heaps (Plates IX and XI). Thus, the Leather Industry loses a good portion of it's raw material through competition, to buyers who use it for food and who are willing to pay more for each skin (plates X and XII).

Trade in skins is an important source of income and foreign exchange. Large Tanneries have sprung up in different parts of the country to handle the bulk of the animal skins collected from the net-work of abattoirs and local slaughter houses. The Leather Industrialist has mounted campaigns to discourage the use of skins for food, insisting that it's nutritional value is very low and therefore wasteful to consume it as food. Nothing, however, is mentioned about skins as possible sources of mineral elements which are so much needed by man and other animals for proper growth and health.

Mineral elements play a vital role in the general physiology of the animal. They have been detected in measurable quantities by various workers in the sheep, rat, cattle and pig skins (Roday, et al, 1940; Leutsker, et al, 1946; Dick, A.T. 1954), Alaskan Moose hair (Flynn, et al, 1973), dog, mouse, guinea pig skins, etc. In most of these works very little is mentioned about goat skins. Furthermore no data are available on the mineral composition of the skins

of goats from the Guinea Savannah region of Nigeria. It's nutritional value has not been determined.

STATEMENT OF THE RESEARCH PROBLEM

In this study attempts will be made to :-

1. determine if such physiologically important mineral elements as Calcium, Sodium, Potassium, Magnesium, Iron, Zinc, Copper, Nickel and Cobalt, are present in the skin of a typical Nigerian goat;

2. measure the quantity of each element present in relation to the area of the skin where such element is found;

3. produce a mineral element map of the goat skin; and

4. evaluate the Nigeria Guinea Savannah goatskin as a source of mineral elements.

RESEARCH METHOD

A comparative and exploratory approach will be employed in this study. The hair of the skin will be regarded as an integral part of the skin since, in practice, it is not possible to remove the hair completely from its root without changing, either by addition or subtraction of substances, by deformation or damage, the basic anatomical and chemical structure of the skin proper. The mineral composition of the skin will be determined from the ashed skin by employing standard chemical analytical methods. The data obtained will be subjected to statistical analyses at the computer centre. The

physiological implications of the results will then be discussed in relation to the economic importance of the goat skin.

The goats used in the research work were randomly selected from a collection of these animals assembled from different local government areas of the old Zaria province of Kaduna State, in the Northern Guinea Savannah zone of Nigeria (fig. 4). The animals were of varying heights, weights, ages, colour and maturity but all had healthy skins with no visible brands or marks. Their colour was the normal light to dark brown.

DATA COLLECTION

The age, sex, body size (in terms of weight and length) of the livcanimals will be determined. The fresh whole skin will also be weighed . The concentrations of mineral elements in the individual whole skin will be determined. Correlation tables will be drawn up and correlation coefficients for different pairs of parameters (paired data) obtained. Equations linking the different pairs of data will be derived.

The use of biological features of each experimental animal will be employed in characterizing the animals and hence determining the species. The size, in terms of weight and length will be measured using scales and measuring tape (for weight and length respectively).

Solutions of the ash of each skin sample will be prepared and caliberated instruments used in determining the mineral ion content. All instruments and techniques

that will be employed in the data collection will be those that have been successfully used for similar experimental analysis and recommended by the Association of Analytical Chemists in "Official Methos of Analysis" (A.O.A.C. 1970) and also recommended by the society for Analytical Chemistry in "Official, Standardized and Recommended Methods of Analysis (S.A.C. 1973).



PLATE III. The dwarf black goat of Southern Nigeria mating a Guinea Savannah brown goat.



PLATE IV. The goats (brown) and sheep (white) here feed from the rubbish heaps.



PLATE I. Typical Guinea Savannah goats. A horned nanny-goat with two kids. The brown colour is typical of the Northern Guinea Savannah goats which are same as the Kano browns.



PLATE II. Collection of goats from different local government areas in Zaria. Out of a total of sixty-seven goats only two were black.



PLATE V. Feeding from a rubbish heap. A wide range of materials constitute food materials for the goat.



PLATE VI. The Guinea Savannah pasture lands. Cattle, Sheep and goats easily move among the herbs and shrubs to forage for food.



PLATE VII. Open Savannah woodland with tussocky grasses, shrubs and trees. Bush fires and farming have reduced this vast area of land into it's present form.



PLATE VIII. Skins being roasted over fire. The hair are completely burnt off. Charred surface is scrapped off with the knife edge.



PLATE IX. Chunks of roast skins in heaps for sale.



PLATE X. Serious business in roast skins done in this whole area.



PLATE XI. Commercializing skins. In the Northern parts of the country these half roasted skins are used for preparing special meat sold ready for eating.



PLATE XII. Skins for home consumption. This Nigerian housewife prepares the freshly flayed skins for her soup pot. A keen competitor for the leather raw material.



PLATE XIII. Dried goat skin (flesh side shown). Punches were made in the ten goat skins used at precisely the positions indicated by the holes.



PLATE XIV. Dried goat skin (grain or hair side). Regions from which samples were punched out are clearly shown.



PLATE XV. Cork borer. This instrument was used for punching out skin samples from the goat skins used for the analyses.



PLATE XVI. Hansen - 125 Scale. This instrument was used for weighing all the goats used for this investigation.

CHAPTER TWO

LITERATURE REVIEW

THE SKIN

DEFINITION

The Dictionary of life Sciences (Martin ed. 1976) defines the skin as "the layer of epithelial cells, connective tissue, and associated structures that covers almost the entire body surface of vertebrates". The skin is said to consist of two layers, namely:- (i) the Epidermis which is an outer layer of epithelial cells derived from ectoderm, and (ii) the dermis (or Corium), which underlies the epidermis. This dermis is made up of connective tissue derived from mesoderm. Loose subcutaneous tissue attaches the skin to the body organs and allows it to move easily over the underlying structures. According to the Websters New International Dictionary (Meriam Webster, 1950) the skin is the intergument of an animal, separated from the body and may or may not have hair.

STRUCTURE

A. The anatomy of the skin as seen in transverse section (fig. 1) reveals that the skin is made up of three distinct layers, namely:- an outer layer called the EPIDERMIS, a middle layer called the DERMIS (OR CORIUM) and an inner layer called the HYPODERMIS (some times referred to as the FLESH layer).

(i) The Epidermis. This layer is divided up into an inner layer, called the Malpighian layer, which consists of viable cells, and an outer layer of horny

cells all cemented together in friction areas.

In the friction areas, such as the soles of the limbs, where the epidermis is very thick, there is a hyalin layer lying between the malpighian and horny layers. This hylin layer is of variable thickness and remains mostly unstained in histological preparations (Montagna and Parakkal - 1974). Conventionally, the malpighian layer is sub-divided into (a) an innermost basal layer one cell deep (called the "stratum basale" or "stratum germinativum") in contact with the dermis; (b) a prickle or spincus layer of variable thickness above it (called the stratum spinosum) and (c) a granular layer (called the stratum granulosum) which contains variously sized keratohyalin granules that are easily stainable with basic dyes (Montagna and Parakkal - 1974)..

(ii) The Dermis (Corium) - This portion consists basically of a matrix of loose connective tissue composed of the fibrous proteins collagen, elastin and reticulin embedded in an amorphous ground substance, referred to as ground matrix in fig. 1. The matrix is traversed by blood vessels, nerves, lymphatics and a network of fibres. The epidermal appendages : eccrine sweat glands, apocrine glands and the pilosebaceous units are also embedded in the ground matrix. The hair root which gives rise to the hair of the skin is also embedded in the matrix (Montagna and Parakkal - 1974).

The dermal matrix contains few cells which are predominantly fibroblasts. These fibroblasts have the potential to produce most, if not all, of the components

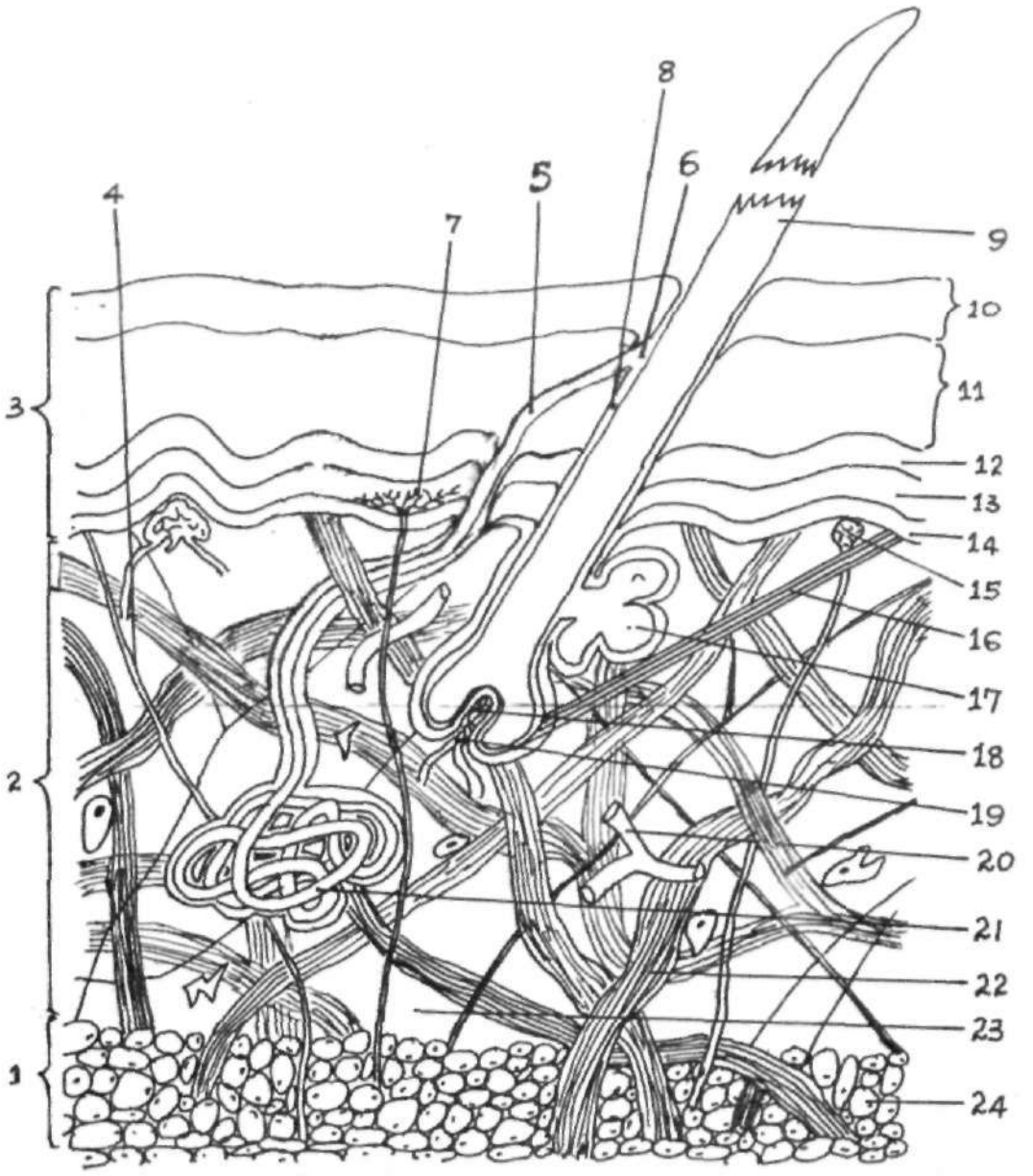


Fig. 1. Transverse section of goat skin (Adapted. Vines and Rees, 1968)
1. Hypodermis, 2. Dermis, 3. Epidermis, 4. Elastic tissue, 5. sweat duct, 6. Sweat pore, 7. Nerve ending 8. Hair follicle, 9. Hair shaft, 10. Stratum corneum 11. Stratum lucidum, 12. Stratum granulosum, 13. Stratum spinosum, 14. stratum germinativum, 15. Tactile nerve ending, 16. Errector muscle. 17. Sebaceous gland, 18. Dermal papilla, 19. Capillary net-work, 20. Blood vessel, 21. Sudoriparous gland, 22. Collagen fibre bundle, 23. Ground matrix, 24. Fat cell.

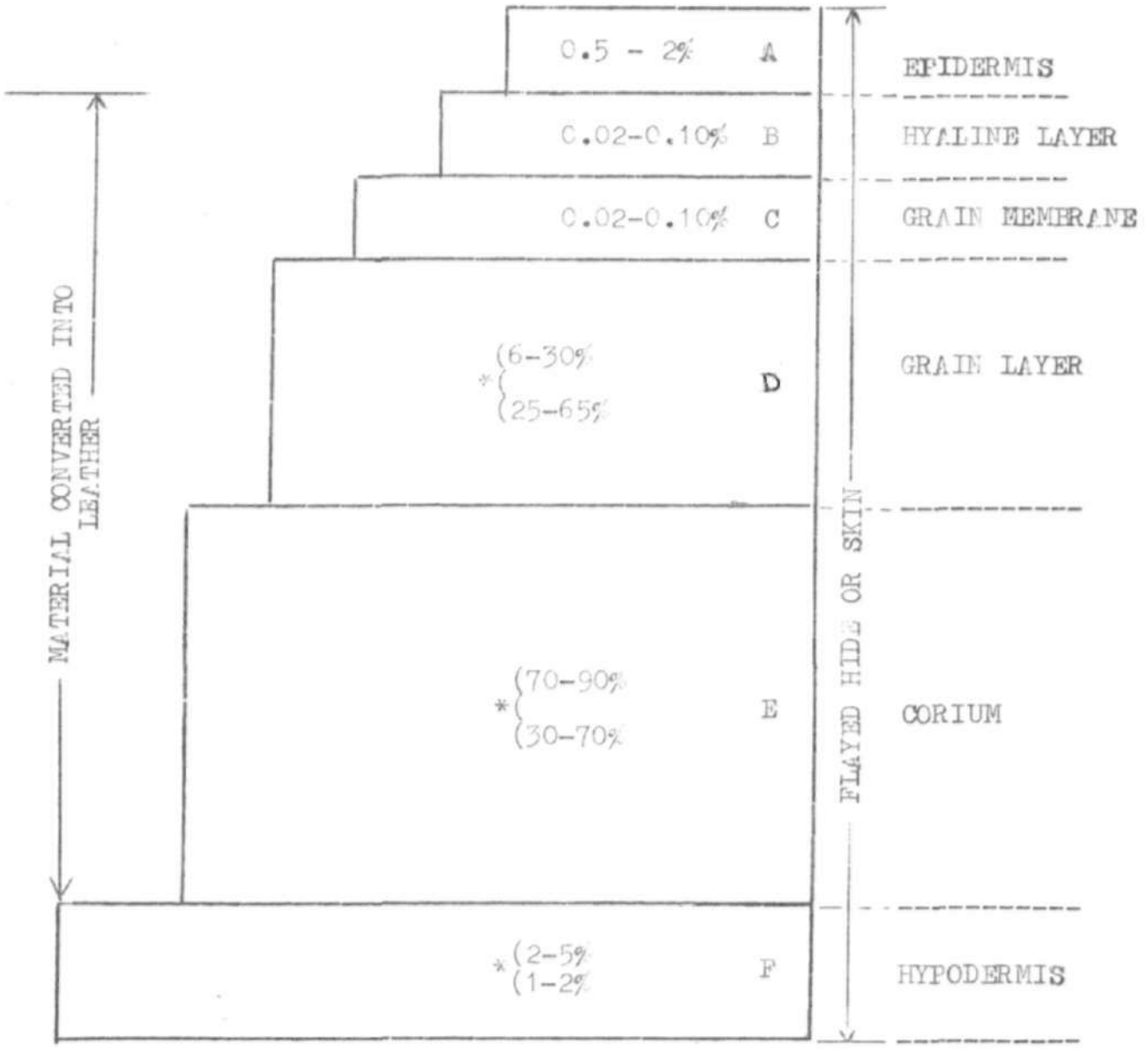
of the extracellular matrix. Mast cells are abundant. Other cells present are hystiocytes or macrophages, melanocytes and leucocytes (Montagna and Parakkal, 1974). The ground substance itself is a gel or sol which does not leak out of the dermis even under pressure. It is normally impermeable to micro-organisms and to injected dyes. It appears to be a multicomponent system of :-

1. substances derived from the blood such as water, inorganic ions, blood sugars, blood proteins and urea, 2. metabollic products of parenchymal cells, and 3. metabollic products of connective tissue cells: the soluble precursors of the fibrous proteins and proteoglycans, glycoproteins and complexes formed from these (Dorfman, 1953).

(iii) The hypodermis (or flesh layer), as shown in fig.1, is composed mainly of fat cells that may be several layers thick depending on the species of animal, it's state of health, food intake , and part of the skin.

B. Structural Characteristics of the goat skin.

The structure of the skin described above and illustrated in fig. 1 is a generalized one describing the mammalian skin and is based on the histological findings of early workers who used human skins mainly for their study. Numerous histological illustrations of other animal skins from the work of different workers now exist; some of these for cattle, sheep, goat, horse, elephant, may be found in monographs of "Indian skins and hides" prepared by the Central Leather Research Institute of India (Nayudamma (ed.,) 1963).



(Adapted from diagram in "Indian Hides & Skins" p.5)

FIG.2 Structural layers of the Goat skin. The approximate percentage of the different layers are shown :-

A - Epidermis B - Hyaline layer

C - Grain Membrane D - Grain layer

E - Corium F - Hypodermis (Flesh layer)

In the Goat skin the layers A,B,C, and D together have been referred to as the epidermis and E as the corium. The Epidermis and corium are nearly equal in thickness in the Goat skin.

* The Upper and lower figures are for hides and skins respectively.

Roddy (1956) in "Histology of Animal Skins" writes that the fresh goat skin has a structure which is similar in some respects to calf skin and in other respects to sheep skin but the total structure is typical in character. The hair side of the goat skin shows both large and fine hair, the latter resembling the wool of sheep. According to him, the oil glands are large and many lobed as in sheep skin while in cross section the goat is similar in structure to calf skin, having the epidermis and corium as making up equal halves of the total depth of the skin. This fact is indicated in fig. 2.

The collagenous fibre bundles in the corium and epidermal areas of the goat skin are very fine. Those in the corium intertwine at a low angle of weave while in the calf skin they intertwine at a high angle of weave. The bundles generally resemble those of sheep skin but are more compactly intertwined. Burns (1965) supplies more information on the histology of the goat skin, particularly the Guinea savannah goat skins of Northern Nigeria. She writes that the over hairs vary in length and coarseness, but that within a fairly narrow range. The undercoat of the goat skin consists of minute, straight hairlets that are not readily visible to the naked eye. The smallest hairlets have very little pigment while the overhairs have most pigmentation. Her investigations revealed that hair samples of goats from the Guinea Savannah regions had lengths of over three centimetres in the back-bone and tail regions and

a mean hair density of 238.8 hair/cm^2. The secondary follicles in all breeds of goats whose skin histology she studied were very small and, according to her, many did not penetrate to the sebaceous gland level of the primary follicles.

BIOLOGICAL FUNCTIONS

a. The Dermis

(i) Protection :- The dermis is uniquely constructed to resist tearing, shearing, and localized pressure but is also flexible enough to allow the movement of the joints and local stretch, thus affording the body protection from external injury. It is mainly the collagen which is arranged in a loose fibrous net-work that provides resistance to mechanical stress. The ground substance in it's meshes provides resistance to compression and bulk flow. The elastic fibres are thought to restore the morphology of the collagen net-work after deformation but the function of the reticulum is unknown (Montagna and Parakkal, 1974).

(ii). Barrier to infection :- The hyluronic acid present in the ground matrix acts as a barrier to most bacteria (Winsor and Burch, 1944).

(iii). Water binding :- The hyaluronic acid also binds water and maintains dermal tugor in the tissues.

(iv). Ion exchange :- The corium may be described as a cation "sink" and, according to Lockwood (1966), the concentrations of the cations here are significantly higher than those in the blood. Such a reservoir may

provide ions for the maintennance of proper levels of blood cation thus serving a homeostatic function and may as well serve in supplying mineral metabolism in general (Montagna and Parakkal, 1974).

b. The Epidermis

By outwardly directed divisions during cell differentiation, the epidermal cells become constituents of the horny layer which shields the animal against damage from the environment and maintains the "internal milieu". Winsor and Burch, (1944) have stated that any form of mechanical or chemical alteration in this layer (the horny layer) will impair it's "barrier" function and will make the skin permeable to water and soluble substances.

Montagna and Parakkal (1974) write that the major functions of the stratum corneum are associated with it's low permeability properties adducing that it not only effectively retards water loss from the inner hydrated layers but also prevents the entrance of most toxic agents.

Generally then, it can be said that the epidermis of the skin serves protective, limiting and aesthetic functions. The pigments of the skin are found in the epidermis and the colour so imparted to the skin and it's hairs by reason of the pigments may serve a protective function in terms of camouflage. The colours usually give the animal an aesthetic appeal.

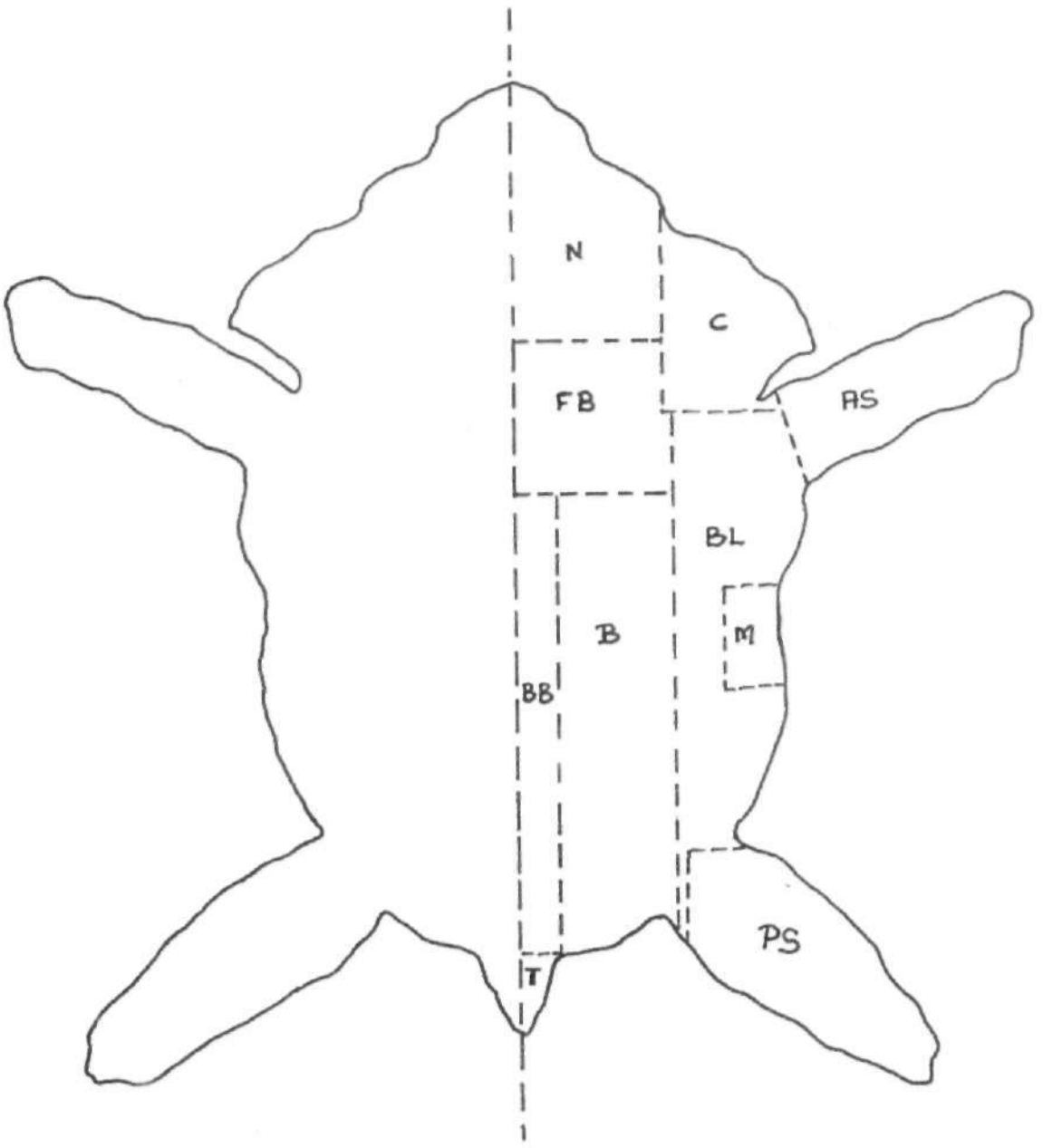


Fig. 3. Flayed goat skin.

N = Neck, C = Chest, FB = Front Butt,
AS = Anterior shank, BL = Belly, B = Butt,
M = Mammary area, BB = Back-bone, PS = Posterior shank, T = Tail

c. The Hypodermis

The hypodermis functions mainly as a fat reservoir serving an insulating and storage function.

2.1.4 SKINS AS RAW MATERIALS FOR LEATHER MANUFACTURE

Hides and skins, which are the basic raw material for leather manufacture, usually take on the typical shape shown in fig. 3 when spread out, after flaying (see also plates XIII and XIV). From his work Tancous (1955) showed conclusively that, in terms of chemical and structural composition, hides and skins are bilaterally symmetrical though the composition varies from one region of each half to another region of the same half.

Often, to prevent or minimize putrefaction of the hides and skins before processing into leather, the raw stock is salt-cured or air-dried before storage. The salt is normally removed to a large extent by soaking in water before processing into leather. Tancous (1955) showed that there are significant variations in the moisture, ash and nitrogen content of the hides and skins due to position within any given side (or one-half of the hide or skin). He also showed that one third of the cured hide is collagen hide substance. The collagen is mainly present in the dermis (or corium) and therefore the corium becomes the most important part of the hide or skin in leather manufacture.

The hypodermis (or flesh layer) is always removed before processing into leather as it is undesirable because the tannins and other chemicals used in processing the skins cannot easily penetrate the fat layer of the hypodermis which therefore becomes subject to microbial attack with concomitant putrefaction. The process of removing the flesh layer is called defleshing and this is done by manual manipulation or mechanical operation of a beam knife over the flesh surface of the skin. The epidermis, together with the hair, is also generally removed except in those cases where the hair are needed in the finished leather. The process of removing the epidermis is called 'Unhairing' and this is accomplished by a step-wise process of washing (of the raw skin to remove salt and filth), soaking in lime liquors or painting with a lime sulphide paste and finally scraping with the beam knife. What is now left of the raw skin is the dermis (or corium proper) with it's tangle of fibrous and non-fibrous proteins embedded in the ground matrix (fig. 1).

Hides and skins are converted into leather by a tanning process which involves removal (de-liming) of the lime used during the process of unhairing (which liming process swells the entire skin to several times it's original size) with such chemicals as ammonium chloride or lactic acid; treatment with enzymes to give the treated skin a

smoother, silky and slippery grain; porous and flaccid with a "fallen" look. The treatment with enzymes is called bating. After bating, the skin is further pickled with salt and acid solutions, usually sodium chloride and sulphuric acid, to bring down the pH of the skin internal environment to acid pH value before impregnation with mineral ions (called mineral tannage). The tanning process may also be accomplished using vegetable tannins. The tanned skin is now called leather. This leather normally undergoes further processes of degreasing, buffing and then spraying with leather dyes to give what is known as'finished Leather'.

<u>The fate of skin Components during the Process of Leather Manufacture</u>

During liming, saponification of skin fats occurs so that lime soaps are formed. Much of the phospholipids are removed according to Mclaughlin (1928). Wood (1914) stated that one of the useful actions of liming is the dissolving of interfibrillar substance, with the consequent separation of the fibre bundles into their finer constituent fibrils so that these are enabled to take active part in the tanning process since the tanning process is largely the impregnation of the collagen (called hide substance) with metal ions or vegetable tannins. Thus, liming purifies the collagen and loosens the

elastic, muscular and reticular tissues of the grain layer and hair.

The bating process, according to Wilson(1928) hydrolises degraded keratinous matter, helping to elimininate them from the skin. In addition several other workers have stated that hair roots, fine hairs, pigments, sebaceous and sweat glands, decomposed cellular debris and degradation products of skin fibres are removed during bating and liming.

The tanning process, which is the major process in leather manufacture, impregnates the collagen fibres with mineral ions (in case of mineral tannage) or brings about a chemical change in the gelatin constituent protein by interaction with the tannic acid of vegetable tannins (in case of vegetable tannage) so that the overall effect of tannage on hides and skins is that they are rendered imputriscible, plyable, supple, tough, wear resisting and usable for the manufacture of leather goods (Lollar, R.M., 1958).

2.2.0. THE GOAT

2.2.1 Classification

The goat according to the classification of Simpson (1945) is classified as shown below :-

KINGDOM	-	Animalia
SUB-KINGDOM	-	Metazoa
PHYLUM	-	Chordata
SUB-PHYLUM	-	Craniata
SUPER -CLASS	-	Gnathostomata
CLASS	-	Mammalia
SUB-CLASS	-	Theria
INFRA-CLASS	-	Eutheria
COHORT	-	Ferungulata
SUPER -ORDER	-	Paraxonia
ORDER	-	Artiodactyla
SUB-ORDER	-	Ruminantia
INFRA-ORDER	-	Pecora
FAMILY	-	Bovidae
GENUS	-	Capra
SPECIES	-	hircus

Ellerman and Morison-Scott (1951) in "Chesklist of Palaearctic and Indian mammals" divided the genus Capra into the following species, namely :-

1. Capra hircus, the true goat, including the bezoar (Capra hircus aegagrus)
2. Capra ibex, the ibexes
3. Capra caucasica, typified by the Caucasian tur
4. Capra pyrenaica, the spanish ibex
5. Capra falconeri, the markhor

These, accordng to them, are the possible wild ancestors of the domestic goat.

The domestic goat with which this study is concerned, is made up of such a wide variety resulting from crossing breeds and such influences as climatic, environmental and human factors. As such it becomes difficult to group them into strains.

According to Devendra and Burns (1970) in their book "Goat production in the Tropics" at least four different methods of classifying the domestic goat have been used, namely:

(i) Origin (webster and Wilson, 1966)
(ii) Body size (Epstein, 1953; Mason 1951)
(iii) Ear shape and length (Mason and Maule , 1950)
(iv) Function (Williamson and Payne, 1965)

Each method has it's merits and demerits. The origin of a great majority of the different breeds cannot be traced. The body size may depend on the state of health of the animal and the nutrient material available to it. The ear shape (lop or prick) and length, according to Devendra and Burns have been applied successfully by Mason and Maule (1960) in classifying goats from East and South Africa, while Mason (1951) arbitrarily divided those of West Africa in terms of body size. Devendra and Burns applied a descriptive method associating each breed of goats with

the very locality where it is found, and in this study the same method is followed, hence the application of the term "Northern Guinea Savannah Goats of Nigeria" to describe the breed of Capra hircus (Linneus) that has been used in this study (see plate I)

Beaton (1939) divides Nigerian goats into geographical colour varieties such as Sokoto red, Kano brown, (Plate II), Bornu white, Damagaran dapple grey, in addition to the dwarf black (Plate III) of the South. According to Gates (1950), these goats are of all sizes but larger than the dwarf black. Mason (1951) places the West African goats into three groups, namely :-

1. the SAHEL long - legged goats with short fine coat weighing between 25 and 35 kg between 70 and 85 cm tall
2. The SOKOTO (intermediate) with highly priced skin and having a weight range of between 20 - 25 kg and an average height of 63cm. These, with several other varieties are intermediate in size between the Sahel goats and the Fouta Djallon dwarf
3. The FOUTA DJALLON dwarf goats (Plate III) of Southern parts of West Africa which are between 40 and 50cm in height and about 18 to 20 kg in weight.

2.2.2 Hair distribution on the Goat Skin

Work done in the Leather Research Institute of India in Madras on goat skins and published in "Indian Hides and Skins - A Monograph (Nayudama 1963) shows that on the average the Butt region of the skin contains the greatest number of hairs per square inch followed closely by the back-bone whose hair and those found in the Tail region are the longest in all species of goats that are not bearded. In the male goats however the beard is usually the longest in those species that are bearded. Published figures of hair numbers are as shown below:-

NECK	BACK-BONE	BUTT	BELLY
7,500	9,000	9,500	6,000

These figures represent average hair numbers per square inch of skin surface. The Belly represents what is normally divided up as mammary area, chest and Belly proper. The Butt includes the front Butt. The back-bone of the skin extends to the base of the tail

2.2.3 Distribution and Feeding habits.

In Nigeria, figures obtained from the Federal office of statistics in 1977 and published in an ILCA Monograph 2 shows that goats are more numerous than either sheep or cattle. Figures indicate that goats at that time were over 23, 146,000; sheep were over 18,099,000 and cattle were over 8,235,000 in numbers. In some parts of the country however, goats may be slightly fewer in numbers than sheep as may be glimpsed from a recent livestock population count undertaken in Gongola State of Nigeria in October, 1982, and published by the New Nigerian (1982) Newspaper as shown in Table 2.1.

The number and distribution of goats, like any other domestic animals, depend on (1) human factors such as man's need for them to solve some of his domestic problems; (2) Natural factors such as its fecundity (reproductive capacity) and ability to adapt to new environments, (3) Availability of nutrient materials (4) Geographical factors such as climate, vegetation, soil type and topography, etc. (5) Epidemiology of the place, etc.

According to the recent studies undertaken by the F.A.O. (Food and Agricultural Organization of the United Nations) on "The trypanotolerant Livestock of West and Central Africa", the dwarf variety of the domestic goat - Capra hircus (Linneus)

which are trypanosomiasis tolerant are found mainly in the Rainforest and derived Savannah zones of Southern Nigeria. The report also shows that there is no doubt that goats in the very humid areas of Southern Nigeria tend to be smaller than those in the drier Savannah areas further north.

Goats ranging in colour from deep red of the Sokoto (red goat) type to brown of Kano goat type are found in large numbers in the areas associated with their names in the Savannah and Sudan zones. Large numbers of these goats are found in the Sudan zones of Sokoto, the Sahel regions of Bornu, the Savannah regions of Kano, Zaria and Gongola, the plateau of Jos (Beaton, 1937).

The feeding habits of goats have been described by some authors as destructive. Maher (1943) says that the goat is the major cause of deforestation and soil erosion while Wilson (1957) argues that the goat helps in controlling bush encroachment, especially in parts of Africa where cattle would be hampered by tse-tse flies. Maher (1954) writes that with their mobile upper lips and prehensile tongues goats can graze on very short grass and browse on foliage normally eaten by other domestic livestock. They feed on materials ranging from herbage and tree-bark to skins and cloth as may be seen from plates IV and V.

TABLE 2.1

Livestock population count in Gongola State of Nigeria (1982)

Livestock	Number
Cattle	2,937,096
Sheep	1,895,988
Goats	1,704,566
Pigs	373,468
Donkeys	29,949
Horses	15,807
Poultry	2,426,486

2.2.4 GEOGRAPHICAL FACTORS WHICH PROBABLY AFFECT THE DISTRIBUTION AND MINERALIZATION STATUS OF THE ZARIA GOAT

(a) Vegetation: Fig. 4 below shows the vegetation zones of Nigeria; and the type of vegetation in an area, to a large extent, determines the type of animals that may be found in it. The southern regions are heavily forested with dense vegetation of tall trees and thick tangle of forest plants so that, together with the tse-tse fly infestation often associated with such areas (F.A.O. 1965 - 1980) it is difficult to keep large farm holdings of livestock. The sparser the vegetation the more easily livestock can be moved from one place to the other to forage for food. Thus, the savannah zones readily come into view as pasture land (plate VI).

From fig. 4 it is clearly seen that there are three major types of vegetation recognisable in Nigeria, namely :- (i) the SWAMP forest of the Coast belt, the high forests of the humid South and the savannahs of the sub-humid Middle Belt and North (Buchanan and Pugh, 1955). Over much of the middle Belt and the North, the dry season is severe and protracted, annual rainfall totals drop below 45 inches and forest is replaced by savannah as the climax vegetation, but over large areas vegetation has been degraded by fire and farming into open savannah woodland (plate VII) with tussocky grasses 5 - 10 feet high and short boled, broad - leaved trees up to 50 feet in height. In the Northern

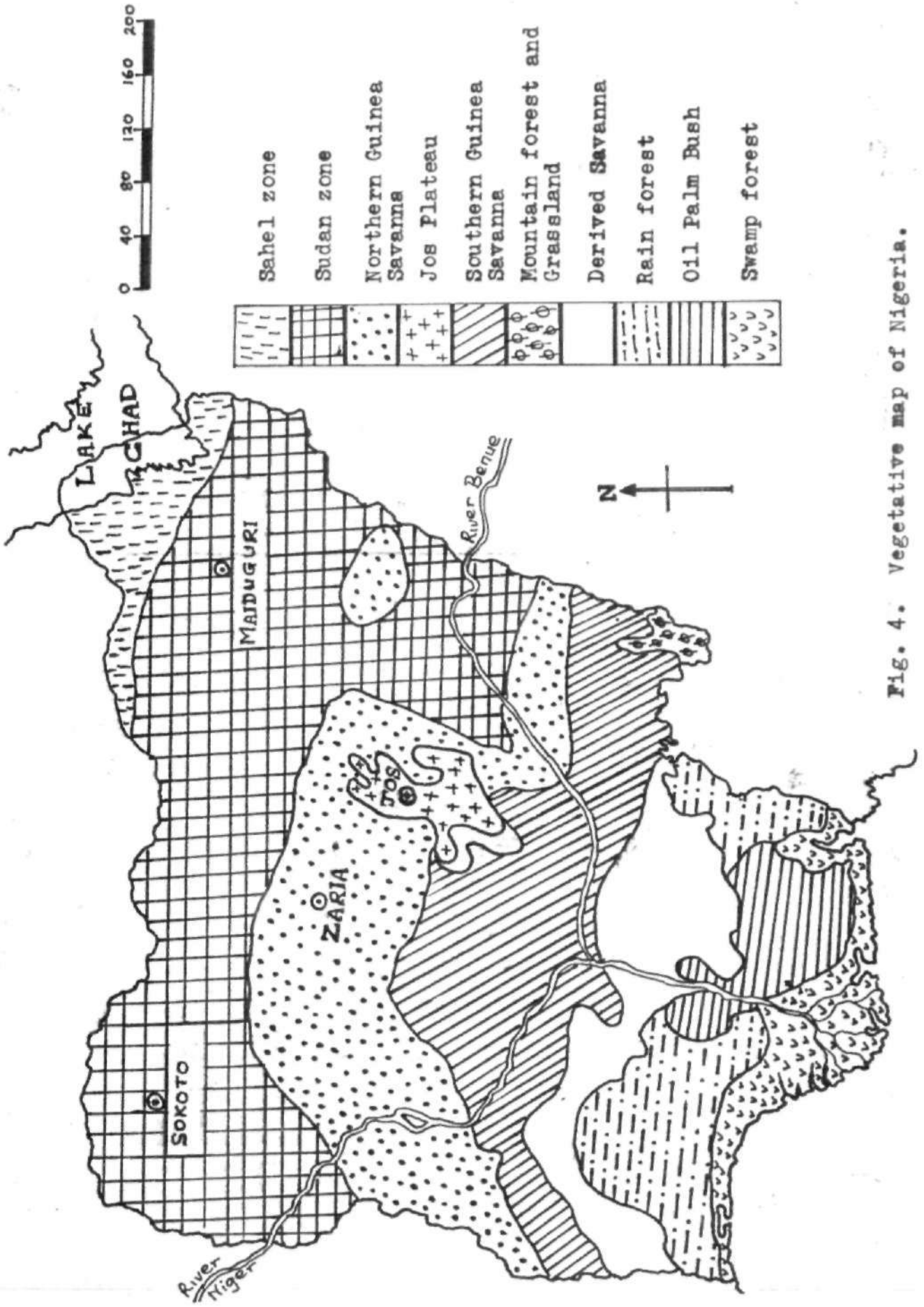


Fig. 4. Vegetative map of Nigeria.

Guinea Savannah zone, usually as a result of cultivation and grazing, the vegetation is relatively open, and grass is dominant (plate VI), though shorter than in the Southern Guinea Savannah zone (Buchanan and Pugh, 1955).

(b) Soil type :- Nigeria covers a total land area of 931,100 square kilometers (F.A.O. 1978). H. Vine (1953) has recently regrouped Nigerian soils into five main classes that are further subdivided into 16 groups. The five main groups are:-

1. Well-drained reddish - coloured soils that range from moderately to strongly leached soils with low humus content.
2. Well-drained soils, moderately leached but with high humus content.
3. Well-drained yellowish-brown soils, excessively leached.
4. Swamp soils.
5. Poorly drained clays and dry sands.

According to Buchanan and Pugh (1955) the first of these classes is by far the most important in terms of area occupied, covering about nine-tenths of the country. In the Savannah area with which this project is concerned two major soil types are distinguishable, namely :- (1) the Zaria type soil which consists of a surface covering of drift deposits about fourteen feet deep in parts mantling the soild sedimentary and basement rocks; this

soil is very fine in texture and is in consequence heavy and relatively difficult to work, tending to become waterlogged with heavy rain and to dry out and crack during the dry season (2) the Northern Drift soils with coarser drift resulting in light sandy soils of buff or reddish colour, of low to medium fertility, easily worked and well suited to crops such as millet and groundnuts. Cotton plants are the characteristic crops in the Zaria type soil (Buchanan and Pugh (1955), pH values of 5.5 - 6.5 in surface layer and 5.0 in the second foot have been recorded (Buchanan and Pugh, 1955).

According to Devendra and Burns (1970), the natural grasslands of West African Savannah regions seldom supplies sufficient Phosphorus to maintain animals in good health for more than a few weeks at the beginning of the rainy season. For most of the year levels are extremely low and are generally below the minimum safety levels. This fact is expected to be so with regards to the Zaria soil with it's waterlogging characteristics such soils being acid (pH 5.0 - 6.5) and are long "known to result in calcium - low forage" (underwood, 1966).

It is clear that the mineral composition of all plants reflects in varying degrees the nature of the soil upon which they grow and this in turn affects the mineral ion status of the animal directly or in directly. Underwood (1966) says that the amount of Potassium, manganese and zinc

carried by plants growing on soils deficient in these minerals is generally adequate to supply the relatively small amounts required by Livestock. Therefore animals of the Guinea Savannah may be expected to have enough of these minerals for their normal needs. The Zaria type soil of the Guinea Savannah is also expected to supply enough cobalt and manganese to plants growing on it and hence indirectly to the animals grazing on such plants since it has been shown that the plant content of these two minerals is greatly increased by soil water logging (Adams and Honeysett, 1964). Molybdenium is normally present in calcareus and alkaline soils made up to a large extent of clay and limestones. Mitchell (1957), demonstrated that the absorption of nickel, cobalt and manganese by plants is favoured by acid conditions.

For grazing animals the soil may also serve as a source of mineral elements. Healy (1973) writes that grazing animals ingest soil along with herbage and this ingested soil can be a source of elements, over and above that contributed by herbage. Ingestion of soil by sheep has been reported in Scotland (Field and Purves (1964) and in Australia (Arnold et al, 1966).

(c) Climate :- Climatic conditions vary throughout the country to some extent. Two major seasons -Rainy and Dry seasons - exist. The rainy season usually extends through a period of seven months (from April to October inclusive), while the dry

season begins from November and ends in March - a period of five months. From map notes by Pugh (1955) in "Land and People in Nigeria" it is clearly indicated that the Savannah regions, including the Sahel, have a total annual rainfall of between 20 and 60 inches while the other regions below the derived Savannah have total annual rainfall of between 60 - 140 (and over) inches of rainfall. The mean annual rainfall for Kaduna State (which includes Zaria) taken for a total period of thirty five years is 51.2 inches. The surface winds throughout the year in Nigeria, according to Buckanan and Pugh (1955) are usually either North-East or South-West Winds with the Intertropical Front Winds sweeping across areas around Kano Southwards in October and Northwards in April. The Winds in the Savannahs are usually fierce because of the open nature of the regions (having relatively few Wind breakers). The other regions south have more wind breakers thus reducing the intensity of the surface winds. During the hamattan of the Dry season the Winds carry much dust. In the Northern regions of the country the temperatures are extreme.

All these factors affect the animals of the the Guinea Savannah both directly and indirectly as they affect the herbage upon which they feed. It is known that a hot dry period hastens the process of maturation in plants while delaying the

production of new, green growth which may be quite different in mineral composition from that of the same plants at a different growth stage, (Underwood, 1966).

2.3 BIOELEMENTS - METALS.

(REQUIREMENT, DISTRIBUTION, AND PHYSIOLOGICAL ROLE IN THE ANIMAL)

General

Mineral elements have long been known to play very important role in the physiology of living organisms. Some, such as Calcium, Phosphorus, Sodium, Potassium, Magnesium, are taken in relatively large amounts and are so needed in the body and are referred to as macronutrients while some others such as Iron, Zinc, Cobalt, Nickel, Manganese, molybdenum are needed in relatively small amounts and so are referred to as micronutrients.

These elements are normally absorbed from the diet of the animal by the body and for grazing animals may also be obtained from ingested soil (Healy, 1973). While some become incorporated into the structural frame work of the body components eg. Iron in haem proteins, others may simply influence metabolic processes or interfere with physical and chemical properties of molecules within the body of the animal. Thus, they become distributed through out the animal body tissues and organs depending on the need for them by the metabolizing cells. Underwood (1966) in his book "the Mineral nutrition of Livestock" itemizes the most important factors which affect the mineral requirement of (and distribution in) animals as (i) the species or breed, (ii) the age, sex and growth rate (iii) the nature and rate of production sought (in

Livestock), (iv) the level and chemical form in which the mineral is ingested (v) the overall balance and adequacy of the diet , in relation to the purpose for which it is given (for Livestock) (vi) hormonal and other physiological activities within the animal (vii) the climate or non-dietary environment and (viii) the cliteria of adequacy employed.

The functions of bioelements in biological systems are many and diverse. Some of the more important include (a) activation of enzyme systems (b) stabilization of proteins in solution (c) Development of electrical excitability (d) Regulation of permeability of membranes and (e) Maintennance of a dynamic state of isotonicity between cells and extracellular fluid (Dyer, 1969).

The valence and atomic number of ions essentially determine their properties and therefore their tendency to form complexes with water and organic molecules. The greater the valency the greater, for instance, the efficiency an ion has in precipitating proteins. (Lockwood, A.F.M. 1966).

An ion which activates an enzyme system may (1) form an integral part with the enzyme molecule (2) serve to link enzyme with substrate (3) cause a shift in the equilibrium position of the reaction or (4) act indirectly by releasing ions which activate the enzyme system.(Lockwood, AFM, 1966).

2.3.1 ZINC

Zinc requirement for normal growth in lambs, calves and goats is not yet known. All that can be stated with certainty is that the requirement of calves lies between 3 and 46 ppm zinc in the whole dry ration (Miller and Miller, 1960). That of lambs lies between 3 and 18ppm (ott et al, 1964). In pigs fed on a basal ration prepared from soya bean meal containing 0.66% Calcium Ca, 0.47% phosphorus and 16ppm Zinc, Smith et al (1958) showed that 45 - 50 ppm zinc is adequate to meet the full nutritional requirements of these animals when the calcium content of the feed is normal, In the experiment, they supplemented the zinc content with zinc oxide to provide total zinc levels of 21, 26, 31, 36, 41 and 46ppm.

An adult 70-kg man is estimated to have 1.4-2.3g zinc in the whole body. This quantity is half the amount of iron, 10 to 15 times that of copper and more than one hundred times that of Manganese in the adult body (Widdowson, et al, 1951). Zinc concentrations of up to 150-250ppm reside in the bones and teeth. This is an appreciable total body concentration.

In the rat and the hedgehog, 38% of the whole body zinc is in the skin and hair, or skin and bristle while in man 20% of this ion is estimated to be in the skin (Pories et al, 1967).

The zinc content of the animal body varies with age and part of the body (Miller et al, 1965). It is preferentially concentrated in healing tissues in rat - skin, muscles and bone fracture (Calhoun and Smith, 1968). It's level in bone and hair can be raised by high dietary intakes and reduced to some extent in zinc deficiency (Dories and Strain, 1967). High inorganic phosphorus intakes can aggravate zinc deficiency in rats, Cadmium in poultry, pigs and calves (Towel et al , 1964). Most rapid accumulation and turn over rate of retained zinc occurs in the pancreas, liver, kidney and spleen (Heath and Liquier, 1950).

Many enzymes are known to require zinc for their physiological processes (Riordan and Vallee, 1976). It is required for growth, health and skeletal development in rats and mice (Todd et al, 1934). The synthesis of nucleoproteins and tissue proteins is profoundly influenced by such mineral elements as Zinc and Magnesium. Zinc ions are involved in DNA synthesis, Williams et al, (1965) showed that there is impaired synthesis in rat liver, depression of ^{32}p incorporation in the nucleotides, and of tritiated thymidine into the DNA of the liver, testis, kidney and spleen. Nason et al (1953) reported that there is impaired synthesis of nucleic acid and proteins in zinc deficiency in micro-organisms. Hsu and Anthony (1974) also observed that zinc-deficient animals have a decreased incorporation of amino acids in the skin

proteins, collagen in particular. Other workers have also confirmed that zinc is essential in DNA synthesis in the mammalian cell. They have shown that it is involved in cell replication and gene expression and in nucleic acid and protein metabolism (Sandstead and shepard, 1968; Rubin, 1972). Pories and Strain (1967), showed that wound healing is promoted by zinc and retarded by it's deficiency.

The importance of zinc in the living organism cannot be overstressed, and this can be glimpsed from the effects of it's deficiency in an animal. Thus, Luecke et al (1973) working with rats showed that zinc deficiency in these animals caused severe lesions (when fed on demineralized casein diet) which included allopecia - a severe exudation, swelling and bleeding of the paws. Numerous bacteria and a few yeast cells were able to grow on the skin surface and between the keratotic layers. There was cracking of the paw with deep fissure.

Under natural conditions, Laboratory and clinical tests performed in Greece on zinc deficient cattle revealed that these animals were characterized by unthrifty appearance, rough coat, loss of hair and enzymatous lesions with thickening and folding in various parts of the skin (Papatheriadis, 1973). The deficiency effects were observed in cattle of all ages.

Work done by Hsu and Anthony (1973) on incorporation of (^{14}C) Glycine - 2 into skin collagen in zinc deficient rats revealed that the water content in the skin of zinc deficient rats was significantly higher than that of zinc supplemented pair fed controls. It is known too that all these deficiency symptoms disappear when adequate supplies of the element is administered to the deficient animal (Hsu and Anthony, 1973).

2.3.2 COPPER

The Copper requirements of rats necessary to maintain pigmentation in the hair are substantially higher than those required for growth (Mills and Murray, 1960) but lesions appear in wool of sheep in some areas at levels of copper intake sufficient to prevent anaemia and other signs of copper deficiency. In their experiment, Mills and Murray (1960), using a diet containing only 0.3 - 0.4ppm copper, estimated the minimum copper requirement for rat of 70 g live weight fed a 10 g diet daily as : for haemoglobin production, 1.0ppm; for growth, 3.0 ppm; for melanin production in hair, 10.0 ppm. 4-6 ppm copper, on dry basis with relatively low molybdenum and inorganic sulphate provide sufficient copper for full requirements of cattle and sheep of British breed and cross-breed. Cartwright (1950) reports that copper balance is maintained in adult man on an intake of 2mg/day.

Hill and Matrone (1962) have reported that there is marked reciprocal zinc - copper antagonism in the animal body. The increase in the quantity of one results in reduction in the activity of the other. Thus, the extent of copper -deficiency occurence depends not merely upon copper intakes but upon the relative proportions of these intakes to dietary levels of zinc, Iron and calcium. Thus, molybdenum and inorganic intake increase can block the functioning of copper in pigmentation (Dick, 1954).

Copper poisoning can occur in sheep and cattle. If liver copper values are very high above critical levels, this may result in the liberation of copper into the blood with resulting haemolysis and jaundice (Howell, 1977). Copper levels of as low as 25ppm can cause copper poisoning in sheep and normal copper intakes with very low molybdenum (0.1-0.2 ppm) can also cause it (Buck, 1970).

Like zinc, the distribution of total body copper varies with species, age and copper status of the animal. Newborn and very young animals are richer in copper per unit body weight than adults of the same species. Figures obtained by various workers give the concentrations of copper in whole body of various species as shown in Table 2.2.

TABLE 2.2

CONCENTRATIONS OF COPPER IN WHOLE BODIES OF VARIOUS SPECIES+

Age	Human	Pig	Cat	Rabbit	Rat	Guninea Pig
Newborn	4.7	3.2	2.9	4.0	4.3	6.9
Adult	1.7	2.5	1.9	1.5	2.0	-

+ Concentrations in ppm of fat-free tissue

Dick (1954) found the total body copper of two adult sheep to be distributed as follows: Liver 72-79%, Muscles 8-12%; skin and wool 9%; skeleton 2%. The glands are examples of low copper tissues; spleen, pancreas and skin and bones represent organs of intermediate copper level; liver, brain, kidneys, heart and hair are relatively high in copper (Cunninghan, 1931). In the brain, copper levels increase with age to about twice from birth to maturity while in other organs - liver, spleen, lungs, aorta - it decreases with age (schroeder et al, 1966). Van kootsveld (1958) obtained copper level of 100 ppm in dairy cattle black hair. He observed that values below 8.0ppm were associated with signs of copper deficiency in cattle. O'Mary et al, (1969) found red and white hair from Hereford cattle to range from 10 to 31 ppm copper with no consistent differences due to colour but with significant effect of season and time of sampling.

Copper is present in a number of metabolically important respiratory enzymes eg. Ascorbic acid oxidase. It plays an important role in respiration as a constituent of oxygen carrying proteins - - Hemocyanin. Undoubtedly too it's functions are related to the pigments found in the skin as discussed below. Flesch (1949) has postulated that copper functions as a catalyst in mammalian

pigmentation, and Marston (1946) also postulated that it functions as a catalyst in keratinization. Abraham and Evans (1973) from their experiment with fed rats showed that the elastin content in the skin of copper - fed rat increased while it tended to increase less in copper deficient rats. Copper ions are involved in the cross-linking of collagen fibres (Rucker et al, 1969; Rucker and Goettlich 1972) and elastin fibres (cleary and Fanning, 1974). Underwood (1966) writes that copper aids deposition of bone in the cartilage matrix.

Copper deficiency results in defects in the processes of keratinization, pigmentation, bone formation, reproduction, myelination of the spinal cord and connective tissue formation. Lee (1956) reported depigmentation of skin of black fleeced sheep with changes in the physical properties of the fibres in copper deficiency. Cleary and Fanning (1974) have stated that in copper deficiency cross-links in elastin fibres cannot be formed so also are the cross-links in collagen fibres (Rucker et al, 1969). Other observations reported in experimental copper ion deficient animals include (i) Reduction in the amount and quality of sheep wool (Underwood,1971) (ii) Specific demyelinating disease of young lambs,called swayback or enzootic ataxia (Lerner et al, 1950), Marston 1946 has shown that the effect of copper on wool

quality is associated with the formation of disulphide cross-links between polypeptide chains in emerging fibres while the ability of inorganic copper to catalyse the oxidation of thiols is well known. Smith and Ellis (1947) have reported the occurence of achromotrichia in copper - deficient rats, guinea pigs, cats, dogs, goats, sheep and cattle but has not been observed in pigs. Mills and Murray (1960) reported the appearance of lesions in wool of sheep.

2.3.3 IRON

Underwood (1966) in The Mineral Nutrition of Livestock writes that little is known of the iron requirements of sheep, cattle, horses or goats. Pigs, poultry and calves according to him have received more attention but even for those species large gaps still exist in our knowledge of iron needs or of the factors influencing them. He further stated that calves fed exclusively with milk diet develope severe iron deficiency anaemia within 8-10 weeks", The results of the experiment by Matrone, et al, (1957) with calves showed that Holstein calves maintained on a basal whole milk diet containing 1 ppm iron on dry basis, alone or with supplemented iron at the rate of 30 or 60 mg per day maintained normal growth and haemoglobin levels for a period of 40 weeks from bith. Thus, minimum iron requirement of calves for growth is

not more than 30 mg/day.

Iron content in a normal 70-kg adult man is about 4-5g or 60-70ppm (Underwood, 1977). This quantity, as has already been mentioned, is twice the total body zinc and more than twenty times the whole body copper. The same proportions of these ions exist in the rat body with about 50 ppm iron. The female rats/mice have greater total body iron. than the males (Underwood, 1977).

In man the liver and spleen carry the highest iron concentrations followed by the kidney, heart, skeletal muscles, pancreas and brain which normally contain $\frac{1}{2} - \frac{1}{10}$ of the concentrations in the liver and spleen. The reserve or storage iron in the body occurs mainly as two haem compounds - ferritin and hemosiderin. (Underwood, 1977).

The factors affecting its absorbtion from the diet include age, iron status, state of health of the animal, conditions within the gastro-intestinal tract and amount of the chemical form of the ingested iron. Mitchell and Hamm (1962) assessed the average loss of iron through the skin of healthy adults as 0.5mg per day. In addition to iron excreted in the urine and faeces, there is continual dermal loss in the sweat, hair and nails.

Inorganic iron compounds possess some oxidative activity and ability to transport electrons, and so they function in living systems in the respiratory process. They are involved in the process of gaseous transfer in the blood stream between the lungs and the cells of the body. Inside the cells they play an important role in forming links in the cytochrome chain (Underwood, 1977).

In iron deficiency in chicks depigmentation of the feathers, unrelated to lack of copper, has been observed (Davis, et al., 1962). Underwood (1966) lists the following clinical characteristics as symptoms of iron deficiency :- poor growth, lethargy, blanching of the visible mucous membranes, increased heart and respiratory rates, decreased resistance to infection, and in severe cases, a high mortality; a progressive development of anaemia of the hypochromic and microcytic type; depletion of storage iron in liver, kidneys and spleen.

2.3.4 COBALT

Horses have long been known to thrive on pasture so low in cobalt content that sheep and cattle grazing upon them waste and die. Reports from New Zealand and Australia indicate that 0.07ppm cobalt in the dry diet was quite adequate for sheep and cattle and this figure has been accepted as the minimum optimal requirement for these

animals while recent evidence indicates that the amount required by lambs is at least 0.10ppm (Andrews,et al, 1958). Ruminants require more cobalt ions than non-ruminants as the microflora of the rumen normally synthesizes vitamin B-12-like substances from the cobalt. The vitamin B-12 normally contains cobalt and is made available to the animal through the rumen (Hedrich et al, 1973).

The element is widely distributed in the body but it has its highest concentrations in the liver, kidney and bones. In one study of normal newborn calves the cobalt content of the tissues ranged from 0.10 - 0.22 ppm on dry basis except for the skin and hair which had 1.0 ppm cobalt ion concentration (Thompson and Ellis, 1947).

Cobalt, like zinc, copper and iron, forms metalloproteins. It is present in vitamin B-12 (cyanocobalamin). Some peptidases in the blood plasma are activated by cobalt and it is an antipernicious anaemia factor (Smith, 1948).

Mineral element deficiency diseases that affect the skin of animals have also been reported for cobalt and Nickel. A deficiency or absence in the diet of animals results, among other symptoms, in dryness of the skin which usually becomes pale and fragile, a gradual loss of appetite and failure of growth or loss of body weight and, in severe cases, severe anaemia culminating in death (Underwood, 1966).

2.3.5 NICKEL

The functions and mode of functioning of Nickel are not clear but it is well known that nickel is an essential trace element needed in very small amounts by animals. Nickel has been detected in man's skin and some other tissues in the animal body (Sunderman, et al, 1972). Nielson (1973) in his work with the chick was able to produce nickel deficiency conditions which caused changes in the shank skin pigmentation and brought about a pathological condition - dermatitis of the shank skin. Nickel is bound to RNA (Dyer,I.A. 1969).

2.3.6 MAGNESIUM

Mitchell (1947) from his work on chick and calf gave the normal Magnesium ion requirement for the two animals as 0.04 % and 0.07 % of the dry diet respectively. Miller et al, (1965) placed that for baby pigs fed on a purified diet at 0.0325% (325 ppm). Blaxter and McGill (1956) reported that pastures or rations containing not less than 0.07% Mg of the dry ration sustained sheep and cattle for normal growth while about 0.1% Mg was adequate for the minimum needs of lactating ewes and cows. Nugara and Edwards (1963) fed young chicks with a ration containing 0.6% Calcium and 0.3% Phosphorus. The ration also contained Magnesium. They found that the minimum requirement for Magnesium increased from 0.04% Magnesium in the dry ration to 0.056% when the Phosphorus content

was increased from 0.3% to 0.9%. When the level of dietary Calcium was also raised to 1.2% the Magnesium requirement was found to rise further to 0.059%. Thus, it is clear that the presence of phosphorus and calcium in the diet of the animal influences the Magnesium requirement of that animal.

Data compiled in the Biological Data Handbook of the National Academy of Sciences and edited by William Spector (1956) on the findings of numerous workers show that Magnesium is widely distributed in the body of animals and may be found in enzyme complexes such as Desoxyribonuclease (found in intestinal mucosa) Enolase (in muscles). It is found in the skin, bones, liver, kidney, brain, etc. of vertebrates.

Kruse et al (1932) showed conclusively that magnesium is required for the normal growth of animals. It functions as an essential part of many enzyme systems including phosphoglucomutase in the mitochondria. Plasma and gastrointestinal secretions contain from 1.7 - 2.3 m-eqv of Mg per litre of fluid and about 55% of plasma magnesium is ionized. (Bell et al, 1972).

A deficiency of Magnesium in the body of the animal, according to kruse, et al (1932), results in alopecia and skin lesions of a trophic nature. The clinical signs of this condition in the animal

stiff and stilted movement, twitching of face and ear muscles. Within a few days extreme excitement and violent convulsions develop, then coma sometimes follows and death finally terminates the life of the animal if serum levels of the ion are not increased on time. Magnesium ions are, generally speaking, necessary for nerve impulse transmission, muscle contraction and carbohydrate metabolism. They help decrease tissue irritability (Dyer, 1969).

2.3.7 CALCIUM

The normal serum levels of calcium in Cows is about 10 mg per 100 ml before calving of these animals. Growing children need up to 1.5g calcium per day and adults 0.5g (Williams, 1971). The committee on Animal Nutrition of the National Academy of Sciences published a report in 1945 which has been revised up to 1964 on the nutritional requirements of sheep. The report states that "forage containing from 0.24 to 0.32 % calcium is considered adequate for sheep" (Pope, 1945 - Chairman: Committee).

Calcium, like Magnesium, is widely distributed throughout the animal body and may be found in high concentrations in the bony structures including teeth. Substantial amounts are present in the skin, mammae, blood, etc. (Spector, 1956). It is present as a cementing substance between cells. It is also present inside the cell as an essential component

of calmodulin which is a multifunctional regulatory protein found in cells and containing four Ca^{2+} binding sites (Wai Yiu Cheung, 1980).

Calcium is known as a very important element involved in the building up of the skeletal structure of animals. It is a constituent of some enzymes such as conjugase (found in the pancreas, tissues of the body) and Apirase (found in the liver and muscles) (Spector 1956). It is important in all regulatory functions of cells where calmodulin is involved. It is reported to give stability and adhesiveness to cell surfaces. In growing animals, especially young animals, it is essential for bone and teeth formation. Lactating mammals have increased requirements of this ion for milk production. Williams (1971) in his book "The Metals of Life" writes that "it is also needed for -----, maintaining the correct rhythm of the heart beat and in the conversion of fibrinogen into fibrin to form blood clots".

"If the blood calcium level falls it is replenished by drainage from the bones and eventually osteomalacia (skeletal bone bending) results. It's deficiency in blood plasma causes muscular twitchings and eventually convulsions" (Williams 1971). Calcium deficiency, if prolonged results in abnormalities of bones and teeth, in subnormal growth , development of depraved appetite, impaired

fertility, milk yield and egg production (Dyer, 1969).

2.3.8 SODIUM

Meyer et al (1950) fed weaner pigs on purified diets extremely low in sodium, potassium and chlorine and from their work they found that the dry diet for these animals should contain not less than 0.08 to 0.10% sodium, 0.23 to 0.28% potassium and 0.12 to 0.13% chlorine. Approximate figures were obtained by other workers for sheep and cattle but not with any accuracy. Smith and Ganguli (1967) maintained adult female rats in apparent health for seven months on a diet containing only 0.004% Na.

Sodium is very widespread in distribution in the animal body being present in extracellular fluids and bones. It is present in the skin, brain, muscles, spinal cord, heart, etc. (Spector, 1956). From tables of published values of mineral composition of animal bodies by Widdowson (1950) and other workers (Spector, 1956) it can be seen that in new born mammals (at birth in man, pig, and laboratory animals studied) the Sodium content of the body exceeds that of Potassium but the condition reverses as the animals grow up into adults.

Sodium inhibits some enzyme systems especially those assoicated with glycolysis and is less active than potassium in activating others. It tends to offset the action of small amounts of divalent ions in decreasing the permeability of cell membranes,

being a monovalent ion. It accounts for major part of the osmotic pressure of blood and interstitial fluid being the main cation in extracellular fluids. It indirectly influences the development of action potential of cell membranes of excitable cells by influencing the permeability of the cell membrane. In high concentrations in cells it becomes dangerous since it inhibits some enzyme systems.

It's deficiency results in a craving for salt (Aines and Smith, 1957), declining appetite, unthrifty, haggard with a rough coat, rapid loss of weight and reduction in milk yield; collapse and sudden death may result in high-producing cows which are calving. In growing pigs, poultry and sheep growth is retarded, water consumption increases and protein and energy metabolism impaired (Underwood, E.J. 1966).

2.3.9 POTASSIUM

Potassium ions are required in low amounts in the diet for sheep, Cattle and grazing animals. Telle et al, (1964) found that the level of Potassium necessary for optimum feedlot performance of sheep was between 0.3% and 0.5% of the air-dry ration. For Cattle levels between 0.72 and 0.85% Potassium were found to be adequate.

Potassium is a major component ion of cells, being always present in the internal fluid of living cells. Williams (1971) writes that the ions are found widely distributed throughout the body. It is found in the Skin, the liver, brain, spinal cord, heart, muscles, etc. of vertebrates.

It's concentration in the mitochondria is higher than in the cell sap. It helps in establishing the membrane potential of cells. It activates some enzyme systems such as pyruvic phospherase and fructokinase. It's presence in the extracellular fluid aids the normal extrusion of sodium from cells.

Welt et al. (1960) reviewed the general effects of Potassium deficiency and these include impaired appetite for food, retarded weight gain. In cattle and other livestock clinical signs include pica (a depraved appetite), poor coat, listlessness and unsteady gait; in humans, subjects of experimental depletion of potassium by means of an ion exchange resin and a diet of low potassium content complained of headache, fatigue, irritability, polydispsia and polyuria. In the review, the findings of numerous other workers who used such experimental animals as rats, pigs, dogs, sheep and cattle for their investigations were sited to confirm these deficiency symptoms. Other deficiency effects listed include increased kidney weight and histological evidence of kidney damage, occurence of metabolic alkalosis, urine concentration in man, dog and rat.

2.4 THE RESEARCH AREA

It is clear from the abundance of evidence revealed in literature that minerall elements are an important group of elements which have great impact in biological systems and upon the animals

as a whole. Frequently the physiological effects of the elements (whether at normal, deficient or toxic levels) on the animal are seen on the skin of the animal either as the first visible signs (as in the case of copper deficiency) or as signs of advanced or prolonged effects of the minerals on the animal.

The obvious economic advantages of the skin of medium size (eg. sheep and goats) to large size (eg. cattle) animals as seen in the extent of trade and Industries that revolve round hides and skins cannot be over emphasized.

The functional role of the skin in the animal (including man's skin) is very important both to the animal and to man whom the animals serve.

The Mineral ion status of the hair of an animal has been used to evaluate the mineral ion status of the diet upon which the animal feeds as this reflects the level in the feed [Miller et al, (1965), Reinhold et al, (1968), and Anke and Groppel (1970)].

Much literature abounds on Mineral elements - level, deficiency and toxicity - in the body and skin of such animals as cattle, sheep, rat and other laboratory animals but very little is written on goats as a whole and less so on the Goat Skin. None at all is available on mineralization in Guinea Savannah goats of Nigeria. This project reports the first detailed work on the mineralization of the skin of the Nigerian goat. and focuses attention on

the metal element status of the goat skin and their abundance and distribution in different regions of the goat skin.

CHAPTER THREE

3.0.0. MATERIALS AND METHOD

3.1.0 COLLECTION OF SPECIMENS

From a collection of goats (Plate II) drawn from different local government areas in Zaria (Fig. 3) ten healthy looking goats were randomly selected. They ranged in age from 1 - 3 years. Two of them were not full grown adults while the remaining eight were fully mature. Two of the mature goats were males while the rest were females. All had brown colour except two which were black, brown being the common colour for most goats in this area of the Guinea Savannah. Weight and length measurements of all the animals were taken. They were then slaughtered and flayed on the same day. The major constraint in the procurement of the specimen animals was the finance. This difficulty was overcome by making special arrangements by which means only the skins of the animals were paid for while all physical measurements of each specimen animal were made before the slaughter.

3.2.0. PROCEDURE

3.2.1 Physical Measurements

Before slaughtering, each goat was weighed by substitution method, using a Hansen - 125 scale that has a ± 0.1gm accuracy (Plate XVI). In the method, a boy was weighed alone on the scale and then weighed

again while bearing the goat in his hands. The difference between the two weights gave the weight of the goat. The method was the most suitable under the circumstance as this eliminated the difficulty of having to hold down each goat to the weighing instrument. The scale used was the most readily available.

Length measurements of the different parts of each goat were made using a measuring tape caliberated in centimetres and millimetres. After flaying, the skin of each goat was weighed using another scale. All measurements were recorded (Table 4.1).

From each whole goatskin, sections from ten different areas were punched out (Plates XIII and XIV) using a silver plated cork borer (Plate XV). Samples were taken from a. neck, b. chest, c. anterior shank, d. anterior belly, e. mammary area, f. Posterior shank g. butt, h. back-bone, i. front butt, j. tail. The hair was not removed from the epidermis. Each skin sample was placed in a small labelled 2- ml P.V.C. specimen bottle with air - tight cover, and chilled by refrigeration to prevent putrefaction until analysis was done.

.2.2 Determination of moisture Content.

The moisture content as determined in this experiment is defined as the loss in weight

obtained when the material is dried under the conditions of the procedure. The results will include volatile matter and may be affected by fat oxidation if this occured (S.A.C. 1973).

The chilled skin samples were thawed, weighed and dried in a mechanical convection air oven thermostatically controlled at 102°C for 16 hours. The samples were then placed in dessicators and allowed to cool. They were re-weighed and oven dried again at the same temperature for a further 2 hours. The two hourly drying, cooling and weighing was repeated until the last two readings did not differ by more than 0.001 g. The loss in weight was reported as moisture (A.O.A.C. 1970).

3.2.3 Determination of Ash Content.

The ash content, as determined in this experiment, is the residue obtained after incineration of the material under the conditions of the procedure (S.A.C. 1973).

The dried skin samples were placed in weighed porcelain crucibles (with lids, to prevent any loss of material during ashing). The crucibles were re-weighed together with the samples, and the sample weight was obtained by substitution. The samples were then ashed at 525 °C in a thermostatically controlled muffle furnace until a yellowish white ash was obtained (24 hours). The ash was cooled in a dessicator, weighed, and moistened with deionized distilled water and dried

at low heat. The ash was then reheated at 525°C for one hour and then the temperature was gradually raised to 600°C and heating continued for another four hours. The heating, cooling and weighing were repeated at four hourly intervals until no further change in weight or colour was observed (A.O.A.C. 1970).

Determination of Organic Content

The Organic matter, as determined in this experiment, is the material that is burnt off during ashing of the biological tissue (goat skin). The difference in the weights of the dried skin samples and the ash was taken as the organic matter content and recorded (S.L.T.C., 1965).

Determination of the Mineral Ion Content

(i) Methodology :- The instrumental method of analysis for metal ions was employed. The instruments employed were the A.A.S. Perkin - Elmer model 290 B and the flame Photometer Corning - EEL model ..... . The former was used in the analysis for Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe), Copper (Cu), Nickel (Ni), Cobalt (Co) while the latter was used in the analysis for Sodium (Na) and Potassium (K). For the Atomic Absorption Spectrophotometry the procedure followed was that described by the Manufacturers of the instrument while the procedure followed for the latter

instrument was that described in the Corning-EEL manual for the Flame Photometer.

(ii) Principle of Method used :-

(a) Atomic Absorption Spectrophotometry :- The basis of the method of the A.A.S. is that when an element in the atomic state is thermally excited, a small proportion of the atoms present is raised to a state of energy in which they emit radiation of discrete energies of frequencies characteristic of that element. At the temperature of the flame, however, most of the atoms remain unexcited, that is, they remain in the 'ground - state' in which condition they do not emit, but are able to absorb radiation of the same frequency. In adopting this phenomenon for analytical purposes, as in the A.A.S. the measurement of the frequency of radiation requires an external source that emits the narrow line spectrum of the desired element. According to Walters and Malmstadt (1965) the process can be illustrated as shown below:

$$M + h\nu \text{ (from external source)} \longrightarrow M.$$

Here the analyte is atomized in an atomization system built into the instrument and the decrease in intensity of the appropriate source emission line due to absorption by sample atoms is measured. The measurement is made under conditions in which Beer - Lamberts law is followed, viz:

$$\log \frac{I_o}{I_t} = abc$$

where I_o = intensity of incident light

I_t = intersity of transmitted light

a = molar absorptivity

b = Thickness of medium

c = Concentration

Thus, the concentration is proportional to the log of transmittance.

The chief advantages of the Atomic Absorption spectrophotometry method lie in the fact of its simplicity and high sensitivity for many elements, frequent lack of serious interferences, and commonly has no need for separations of constituent elements of the sample (except simple ones often made more for concentration than for actual separation), rapidity, and satisfactory precision (Sandell and Onishi, 1944) .

(b) Flame Photometry (For Na and K.).

In Flame photometry, the sample after dilution (if necessary) is sprayed into a gas flame of sufficient thermal energy to cause the elements present in it to emit their characteristic radiation. The required spectral emission is isolated by means of a monochromator or filter. The intensity of the emission is measured by means of a photosensitive detector coupled to an amplifier and a recorder. Standard solutions are used for calibrating the instrument using suitable wavelengths. Here again measurements involve the application of Beer - Lamberts Law . The method is recommended for the alkali metals (S.A.C. 1973).

(iii) Preparation of Sample Solutions.

Weighed amounts of each skin sample ash were separately dissolved in 0.5 ml concentrated hydrochloric acid (HCl). 0.5 ml deionized distilled water was then added to each solution. This was followed immediately by the addition of 3.0 ml conc. H_2SO_4. The resulting solutions were transferred quantitatively to 100 ml volumetric flasks and each shaken for two hours using flask - shakers. The flasks were made up to mark with deionized distilled water and vigorously shaken. Final solutions were then transferred into plastic bottles (thoroughly washed and cleaned) to minimize contamination due to pick-ups.

(iv) Preparation of Standard Solutions.

Standard solutions were prepared for the calibration of the instruments as recommended by the society of Analytical Chemistry (1973). All reagents were of the Analar grade (High grade analytical reagent). The water used for preparing the solutions and for rinsing the storage and working vessels were distilled and deionized. All solutions were stored in plastic bottles. Test solutions were also taken up in plastic sample bottles. All weighings were done with the Mettler balance using cellophane sheets.

(a) Calcium Stock Solution.

Calcium carbonate was oven-dried overnight (24 hours) at 105°C and cooled in a dessicator. 2.4973 g. of this was weighed out and placed in glass beaker. Few drops of water were added

followed by careful addition of 10 ml conc. HCl. The solution was warmed on a water-bath. To eliminate interference from aluminium, silicon and sulphate ions during instrumental analysis, 7.5 ml of 1,500 ppm strontium chloride solution was added and the resultant solution was transferred to a one- litre volumetric flask and made up to mark with water.

From the calcium stock solution 3.0, 6.0, 9.0, 12.0 and 15.0 ppm solutions were prepared and used for calibrating the instrument at a wavelength of 422.7 nm (Fig. 7).

(b) Sodium Stock Solution.

2.5418 g. of sodium chloride over-dried at 140°C was measured out into a one litre volumetric flask and made up to mark with water. This solution, now containing an equivalent of 1.0 mg Na/cm^3, was used in preparing standard solutions of strengths 1.0, 2.0, 4.0, 6.0 and 8.0 ppm for calibration of the instrument (Flame Photometer) at wavelength of 589 nm.

(c) Potassium Stock Solution.

1.907 g. Potassium Chloride dried at 110°C was placed in a one - litre volumetric flask and dissolved in water. 7.5 ml of 0.01% Lithium Chloride was added to the solution and made up to mark with water. This was to reduce the ionization that resulted due to the high temperature of the Acetylene flame (1800° - 2000°C) used in the

instrument. (The same amount of Lithium Chloride was added to the test solution before making it up to 100 ml). From this stock solution 3.0, 6.0, 9.0, 12.0 and 15.0 ppm solutions were prepared and used for calibrating the instrument (Flame Photometer) at 766.5 nm wavelength. (Fig. 8).

(d) Magnesium Stock Solution.

1.0 g Magnesium ribbon cleaned with emery paper was cut up into tiny pieces and dissolved in 10 cm^3 Conc. HCl. Resulting solution was evaporated almost to dryness in a water-bath. Water was then added to redissolve, and quantitatively transferred to a one - litre volumetric flask. 7.50 cm^3 strontium chloride of strength 1,500 ppm was added to this solution (while a proportionate volume of 0.75 cm^3 was added to the test solution before making that up to 100 ml mark), and made up to mark with water, in order to minimize interference that may arise if Aluminium, silicon and strontium ions are present in the magnesium ribbon. From the Magnesium stock solution which now contained 1.0mg Mg/cm^3, solutions of strengths 0.5, 1.0, 1.5, 2.0 and 2.5 ppm were prepared and used for calibrating the instrument at a wavelength of 285.2nm.

(e) Zinc Stock Solution.

10 cm^3 conc. HCl was added to 1.0 g pure zinc metal and boiled on a water-bath until all the zinc dissolved. The resulting solution was then transferred quantitatively into a one - litre

volumetric flask and made up to mark with water. From this stock solution which now contains 1,000 ppm Zn ions, 1.0, 2.0, 3.0, 4.0 and 5.0 ppm solutions were prepared and used for calibrating the instrument at a wavelength of 213.9 nm (Fig. 9).

(f) Iron Stock Solution.

1.0 g pure iron wire was cut up into tiny pieces and dissolved in 15.0 cm^3 conc. HCl. The resulting solution was evaporated almost to dryness in a water bath and then transferred quantitatively into a one - litre volumetric flask and made up to one litre water. This stock solution now containing 1,000 ppm Fe ions was used for preparing solutions of strengths 5.0, 10.0, 20.0, 40.0 and 80.0 ppm which were then used for calibrating the instrument at wavelength 248.3 nm.

(g) Copper Stock Solution.

1.0 g pure copper metal was dissolved in 5.0 cm^3 conc. HNO_3 (Nitric Acid). 5.0 cm^3 conc. HCl was then added and the resultant solution was evaporated almost to dryness. Water was added to redissolve and solution was transferred quantitatively into a one - litre volumetric flask and made up to mark with more water. The stock solution now containing 1,000 ppm Cu ions was used in preparing standard solutions of strengths 5.0, 10.0, 20.0, 40.0 and 80.0 ppm. With these the instrument was calibrated at a wavelength of 324.7 nm (Fig. 10).

(h) Cobalt Stock Solution.

0.2385 g $CoSO_4.7H_2O$ (Cobalt Sulphate deca-hydrate) was dissolved in water and made up to one litre in a one litre volumetric flask. This stock solution contained 0.05 mg Co/ml and from it 1.0, 2.0, 3.0, 4.0 and 5.0 ppm standard solutions were prepared and used for calibrating the instrument at a wavelength of 36 7 nm (Fig. 12).

(i) Nickel Stock Solution.

4.953g Nickelous nitrate was dissolved in water, 1.50ml conc. HNO_3 added, and made up to one litre in a one - litre volumetric flask. From this stock solution 1.0, 2.0, 3.0, 4.0 and 5.0 ppm standard solutions were prepared and used for calibrating the instrument at a wavelength of 480 nm (Fig. 11).

CHAPTER FOUR

4.0.0 RESULTS AND OBSERVATIONS

4.1.0 PHYSICAL PARAMETERS

From a general survey made before the specimen animals were selected, it was found that most goats in the Zaria area have brown coats (plate II). In the sample drawn from a large population of goats, two were males and eight were females and their ages ranged from 0.83 to 5.0 years approximately; (as) the ages could only be estimated by the handlers of the goats. Their weights ranged from 14. 0 to 28.0 kg while the total length (from snout to tip of tail) ranged from 0.97 m to 1.33 m. The physical parameters obtained for these goats are given in Table 4.1.

4.2.0 RELATIONSHIPS BETWEEN SOME PHYSICAL VALUES OBTAINED FOR THE GOATS:

4.2.1 Live Body Weight Vs. Total length

Figure 5a shows the regression line obtained when the weight of the animal was plotted against the total length. The coefficient of correlation, r, is 0.6405. The mean live-weight is 21.80 kg while the mean total length is 1.19 m. The equation relating the weight of the animal to it's total length is given as shown below :-

$$L = 0.0142\ B + 0.8854$$

where L = Total length (in metres) and B = body weight (in kg)

The correlation is significant at $P < 0.05$

The table of values for the two parameters is shown below in Table 4.2.

TABLE 4.1

Values of physical measurements made for ten goats - Capra hircus (Linneus)

Parameter	Range	Mean	S.E.
Age	0.83-3.0yrs	2.14yrs	±0.260
Live Weight	14.0-28.00kg	22.36 kg	±1.480
Total length	0.97-1.33 m	1.19 m	±0.030
Weight of fresh skin	0.98-1.83 kg	1.47 kg	±0.110
Chest girth	0.18-0.26 m	0.23 m	±0.009
Circumference of middle trunk	0.54-0.76 m	0.69 m	±0.020
Length of neck	0.12-0.20 m	0.16 m	±0.007
Length of tail	0.10-0.18 m	0.13 m	±0.008
Length of fore-limbs	0.31-0.40 m	0.36 m	±0.010
Length of hind-limbs	0.40-0.49 m	0.44 m	±0.008
Length of left horn	0.05-0.15 m	0.11 m	±0.010
Length of right horn	0.05-0.15 m	0.10 m	±0.010

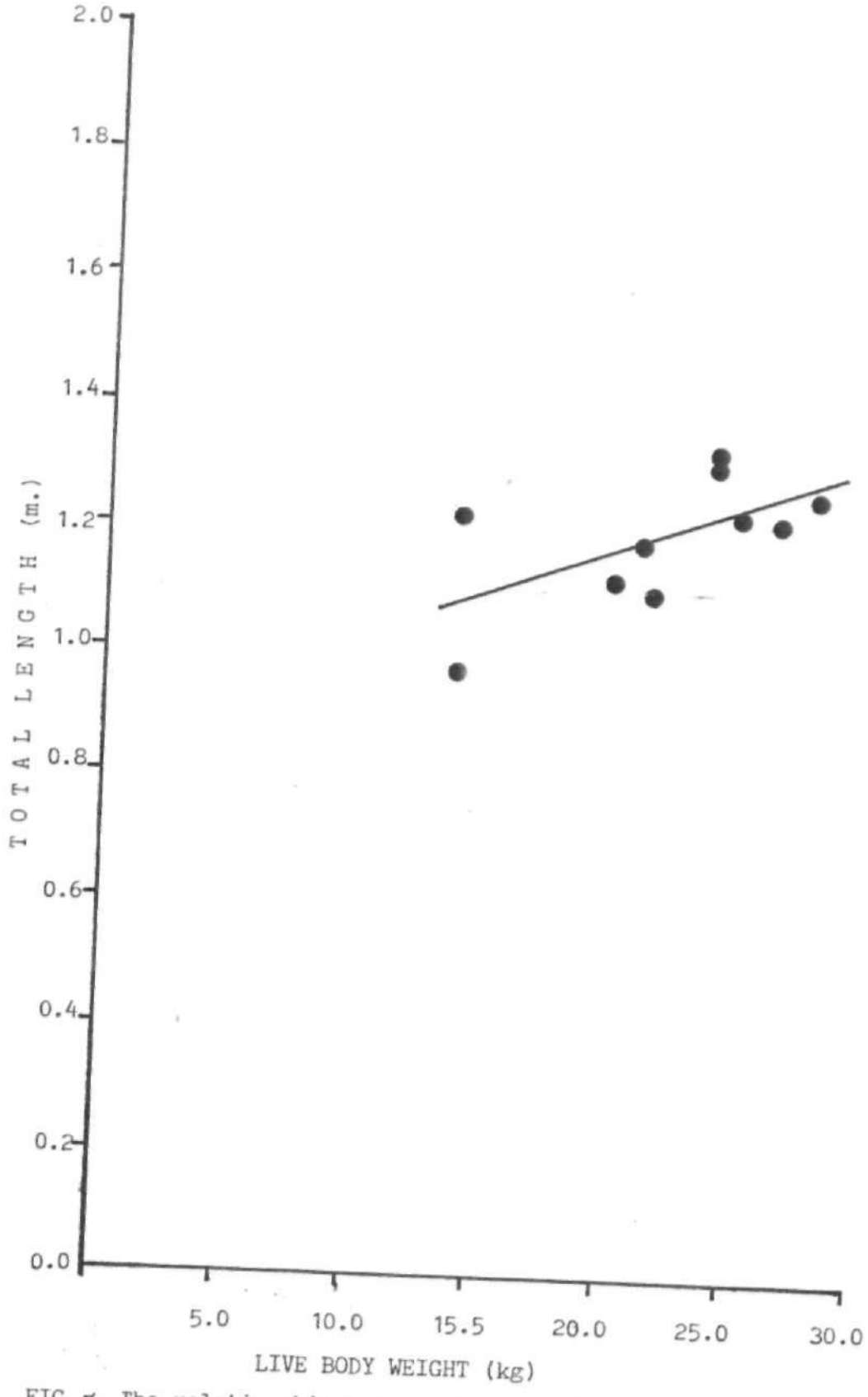


FIG. 5a The relationship between body weight and total length of goat was direct and significant at $P < 0.05$. The correlation coeficient was 0.63.

4.2.2 Body Weight Vs Wet weight of whole skin

From Table 4.3 below the regression line for the live weight of the animal against the wet weight of whole skin was plotted and the coeficient of correlation was found to be 0.6624 at a level of significance of 0.05. The mean weight of the fresh whole skin of the goat is 1.40 kg and the weights ranged from 0.96 - 1.83 kg. The regression line for the data of Table 4.3 is shown in figure 5. The equation relating the body weight and wet weight of whole skin is :-

$$S = 0.0404\ B + 0.5228$$

where S = wet weight of whole skin (in kg) and
B = body weight of goat (in kg).

4.2.3 OTHER PHYSICAL VALUES

Analysis of data for wet skin weight Vs Total length (Fig. 6), Body weight Vs Average horn length, Total length Vs Average horn length, showed that the correlations between these pairs were not significant though the relationships were such that as one increased the other also increased.

CALCULATIONS

The computation of the correlation coefficient r, is based on the following equation :-

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{n\sigma_x\sigma_y}$$

where n = the number of pairs of figures
σ_x and σ_y = the standard deviations of x and y respectively.

TABLE 4.2

Values of live weight and Total length for the ten goats

LIVE WEIGHT (kg)	TOTAL LENGTH (m)
28.00	1.26
20.00	1.12
21.00	1.18
14.00	1.22
24.00	1.33
25.00	1.23
21.50	1.10
24.00	1.31
14.00	0.97
26.50	1.22
MEAN 21.80	1.19
S.E. ± 1.51	± 0.03

EQUATION :-

Total length = 0.0142 x Body Weight + 0.8854

TABLE 4.3

Values of body weight of the goats and the weights of fresh whole goat skins.

BODY WEIGHT (kg)	WET WEIGHT OF SKIN (kg)
28.00	1.747
20.00	1.409
21.00	1.586
14.00	0.956
24.00	1.540
25.00	1.437
21.50	1.825
24.00	1.208
14.00	0.983
26.50	1.347
MEAN 21.80	1.404
S.E. ±1.51	± 0.09

EQUATION:-

Wet weight whole skin = (0.0404 x Body weight) +0.5228

$R = 0.66$

$P < 0.05$

r is a measure of correlation known as the Pearson product - moment coefficient of correlation.

The equations obtained for the regression lines were obtained by solving for a and b in the simultaneous equations :- $\sum y = ar + b\sum x$ where n = no of pairs of figures.

$$\sum xy = a\sum x + b\sum x^2$$

4.3.0 MOISTURE CONTENT

The moisture content for the goat skins determined by the method described in chapter 3 under 'moisture content" is recorded in Table 4.5. The moisture is recorded as percentage of the fresh skin. For each skin the mean moisture for ten samples taken from ten different areas is recorded and the standard error given. The result shows that the moisture content ranges from 56% to 68%. The mean of means is 63.47% with a standard error of $\pm$ 1.07. This moisture, as indicated in Chapter 3, page 67 includes the volatile matter of the skin.

Table 4.6 gives the moisture content of the different segments of each goat skin, with the least in the tail region and the highest in the mammary area. Each value recorded in the table is the mean of ten readings obtained for the same skin region in the ten different goat skins analysed. Thus, the value 64.00% recorded for neck is the mean obtained for corresponding areas of the neck skin of each of the ten goat skins examined. When viewed in

descending order of magnitude, these values show that the moisture in the :-

Mammary area > Anterior belly > Posterior shank > butt > Neck > Chest > Front butt > Anterior shank > back-bone > Tail region

It may be observed here that hair is relatively more abundant and longer in the Tail which has the least moisture content value than in the mammary area where hair is very scanty.

4.4.0 ASH AND ORGANIC MATTER

The ash and organic matter contents of the goat skins are recorded in Tables 4.7 to 4.10. For comperative purposes the values were computed on wet weight basis and or dry weight basis. Tables 4.7 and 4.8 show the Ash and organic matter contents for each goat skin while Tables 4.9 and 4.10 show the ash and organic matter contents for the different sample areas taken from the goat skin. Thus, values here (Tables 4.9 and 4.10) are means for samples taken from corresponding areas of each of ten goat skins.

Table 4.7 gives a range of 1.29 - 2.28% (wet weight) and a range of 3.53 - 6.45% (dry weight basis) for the ash. The mean of means and standard error on wet weight basis are 1.71% and $\pm$ 0.11 respectively. On dry weight basis the mean ash is 4.68% with a standard error of $\pm$ 0.32.

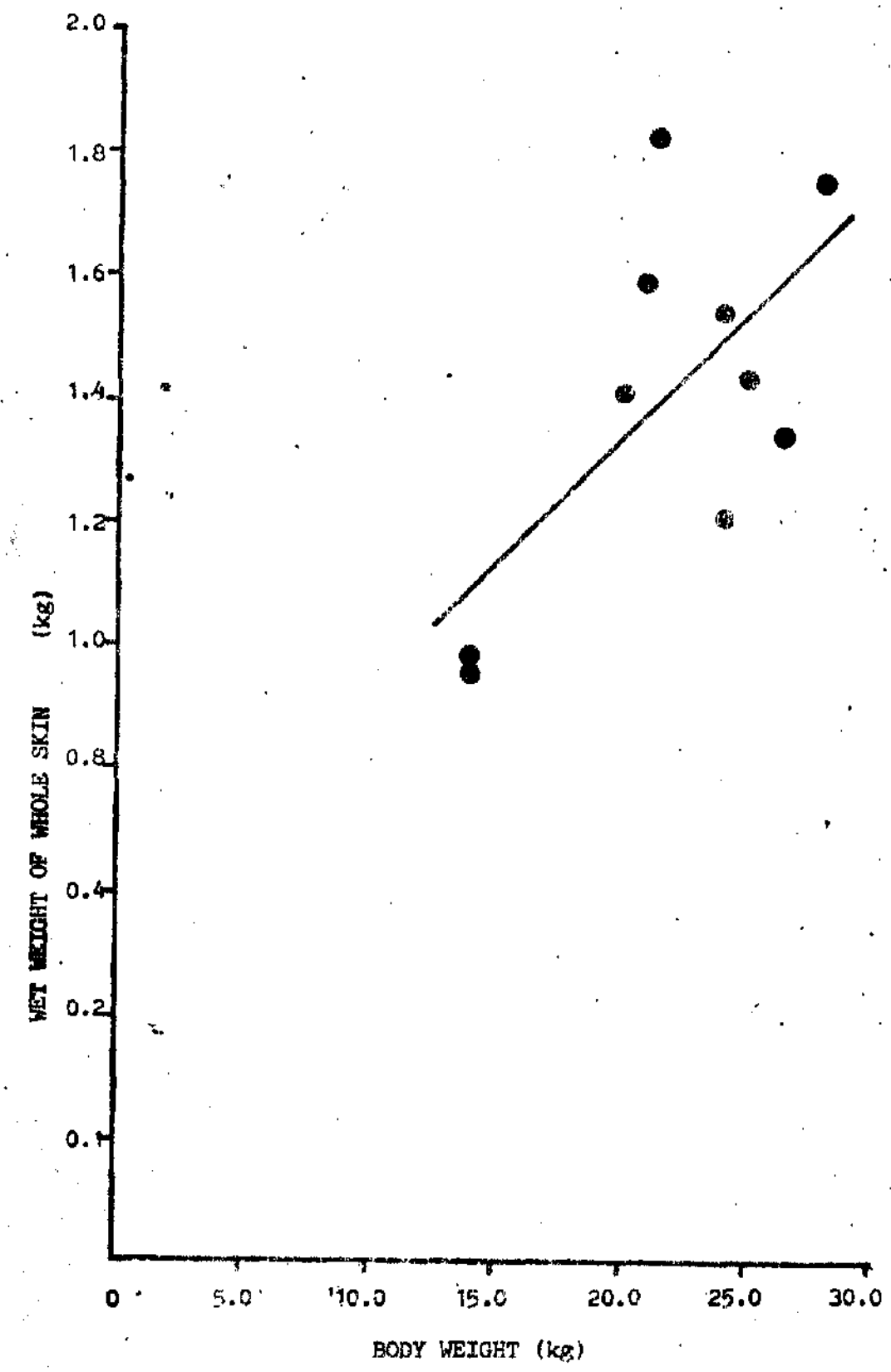


FIG.5. The direct relationship between body weight of goat and wet weight of whole skin was significant at $P < 0.05$ and the correlation coeficient, R was 0.66.

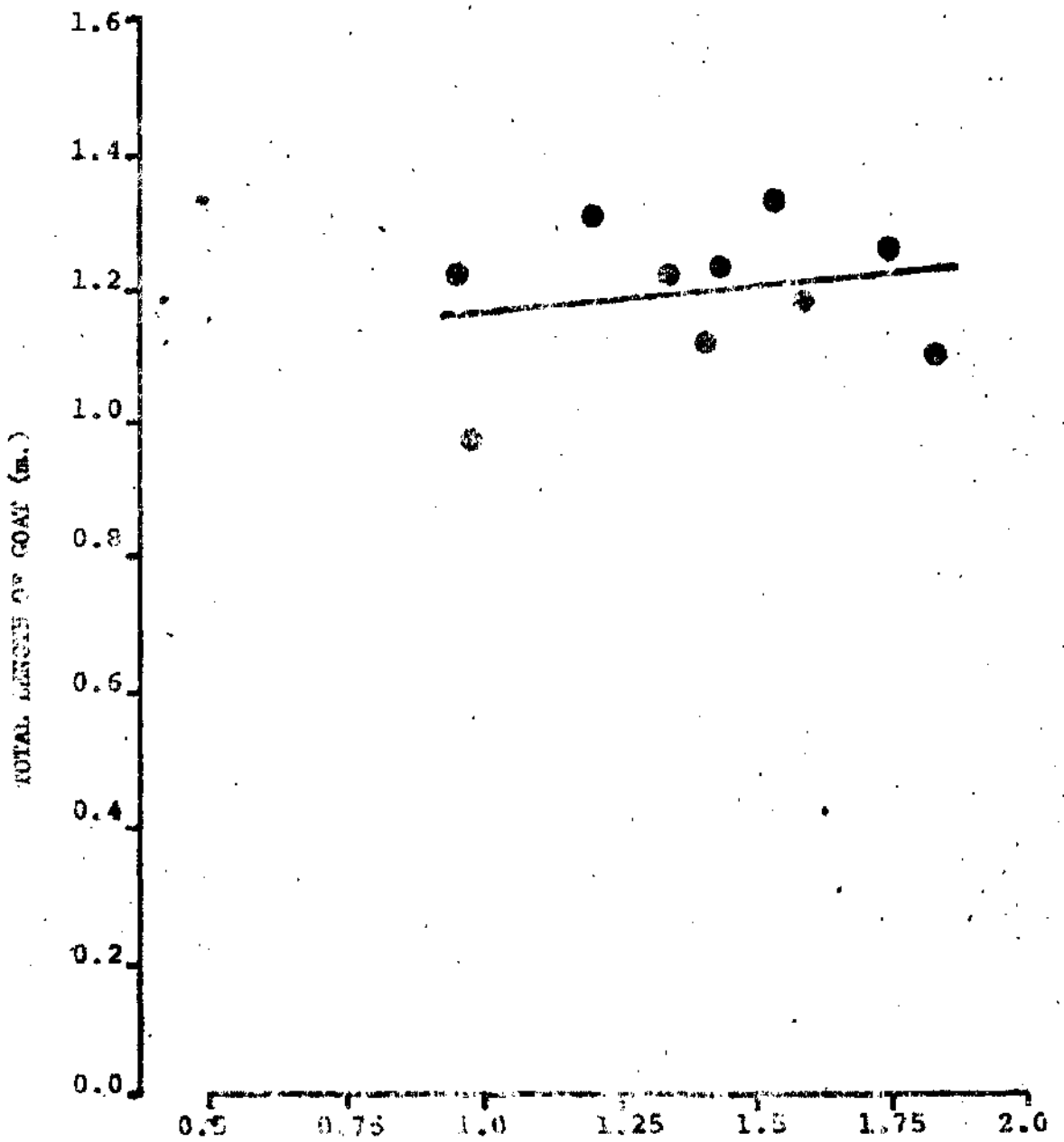


FIG. 6. The relationship between the total length of goat and the wet weight of whole skin though straight was not significant at $P < 0.05$.

TABLE 4.5

Mean values of moisture content for ten different samples taken from each of ten different goat skins numbered 1 - 10

Serial no of Goat Skin	Mean Moisture %	Standard Error
1.	59.36	± 0.03
2.	60.31	± 0.03
3.	56.67	± 0.06
4.	65.59	± 0.03
5.	65.49	± 0.02
6.	67.72	± 0.05
7.	63.79	± 0.05
8.	63.66	± 0.03
9.	66.56	± 0.03
10.	64.54	± 0.02
Range	56.67 - 67.72	
Mean of Means	63.47	
Standard Error	± 1.07	

TABLE 4.6

Average Moisture content for different regions of the goat - skin.

Region of Goat Skin	Mean Moisture %	Standard Error
NECK	64.00	± 0.02
CHEST	63.21	± 0.04
ANTERIOR SHANK	61.57	± 0.04
ANTERIOR BELLY	66.35	± 0.05
MAMMARY AREA	67.44	± 0.06
POSTERIOR SHANK	65.26	± 0.03
BUTT	64.41	± 0.03
BACK - BONE	60.90	± 0.05
FRONT BUTT	61.60	± 0.05
TAIL	57.26	± 0.04

TABLE 4.7

Values for Ash content of goat skins

Serial no of Goat Skin	Mean Ash % (Wet Weight)	Mean of Ash % (Dry Weight)	Standard Error
1.	1.52	3.76	± 0.002
2.	1.87	4.75	± 0.002
3.	1.84	4.22	± 0.003
4.	1.58	4.19	± 0.002
5.	2.28	6.45	± 0.002
6.	2.02	6.20	± 0.003
7.	1.29	3.53	± 0.002
8.	2.03	5.32	± 0.002
9.	1.54	3.98	± 0.001
10.	1.57	4.38	± 0.001
Range	1.29-2.28	3.53-6.45	
Mean of Means	1.71	4.68	
Standard Error	±0.11	±0.32	

TABLE 4.8

Values for organic content of goat skin

Serial no of Goat Skin	Mean Org. matter % (Wet weight)	Mean Org. matter % (Dry Weight)
1.	38.62	96.24
2.	37.32	95.25
3.	41.49	95.78
4.	33.03	95.82
5.	32.23	93.55
6.	30.26	93.80
7.	34.92	96.47
8.	34.31	94.63
9.	32.10	96.02
10.	33.89	95.62
Range	30.26-41.19	93.55-96.63
Mean of Means	34.82	95.32
Standard Error	± 1.08	± 0.32

TABLE 4.9

Ash content of various portions of the goat skin

Portion of Skin	Mean Ash % (Dry Weight)	Mean of Ash % (Wet Weight)	Standard Error
NECK	3.50	1.29	± 0.001
CHEST	3.50	1.28	± 0.001
ANTERIOR SHANK	5.22	2.01	± 0.002
POSTERIOR BELLY	3.43	1.11	± 0.002
MAMMARY AREA	5.40	1.76	± 0.003
POSTERIOR SHANK	5.24	1.82	± 0.002
BUTT	4.09	1.45	± 0.009
BACK-BONE	5.19	2.09	± 0.003
FRONT BUTT	4.85	1.86	± 0.002
TAIL	4.91	2.10	± 0.002

TABLE 4.10

Organic content of various portions of the goat skin

Portion of Skin	Mean Organic matter % (Dry Weight)	Mean Organic matter % (Wet Weight)	Standard Error
NECK	96.50	35.49	± 0.021
CHEST	96.53	35.51	± 0.023
ANTERIOR SHANK	94.78	36.43	± 0.022
POSTERIOR BELLY	96.57	31.24	± 0.032
MAMMARY AREA	98.20	31.97	± 0.030
POSTERIOR SHANK	94.77	32.92	± 0.024
BUTT	95.91	34.13	± 0.024
BACK-BONE	94.81	38.17	± 0.033
FRONT BUTT	95.16	36.38	± 0.031
TAIL	95.09	40.64	± 0.039

Correspondingly Table 4.8 gives the range for organic matter content on wet basis as 30.26 - 41.49% and on dry basis as 93.55 - 96.47%. The mean organic content on wet basis is 34.82% with a standard error of ± 1.08 while on dry basis the mean is 95.32% with a standard error of ± 0.32.

The ash and organic matter content of the various portions of the goat skin recorded in Tables 4.9 and 4.10 indicate that there are differences between the different sample portions. When graded in descending order of abundance the ash in these different portions of skin is relatively abundant in the order shown below :-

Mammary area > Posterior shank > Anterior shank > Back-bone > Tail > Front butt > butt > Neck, chest > Posterior belly, while the organic matter is relatively abundant as shown below (on dry basis) :-

Mammary area > Posterior belly > chest > neck > Butt > Front butt > Tail > Back-bone > Anterior shank > Posterior shank.

4.5.0 THE MINERAL ELEMENTS

.5.1 MINERAL ION CONTENT (COMPOSITION)

From the general instrumentation analysis done on the dissolved goat skin ash, the following metals were detected and measured :-

Calcium (ca)

Sodium (Na)

Potassium (K)

Magnesium (Mg)

Zinc (Zn)

Iron (Fe ,

Copper (Cu)

Nickel (Ni)

Cobalt (Co)

From the total of one hundred goat skin samples taken 10 from each fresh skin, a mean mineral ash of 1.71 g was obtained from 100g fresh skin. From this mineral ash of 1.71 g, the following amount of metal elements were detected :-. Calcium 0.0516 g, Sodium 0.1516 g, Potassium 0.0884 g, Magnesium 0.0200 g, Zinc 0.0197 g, Iron 0.0713, Coper 0.0068 g, Nickel 0.0283 g and Cobalt 0.0127 g. Thus, the mineral ash contains a total of 0.4504 g of the mineral elements investigated.

Table 4.11 gives the detailed result of the analysis of one hundred skin samples. From the results it can be seen that the ash obtainable from 100g of goat skin, under the condition of the experiment, ranges between 1.29 - 2.28 %. Calcium ranges between 0.03 and 0.09%, Sodium 0.07-0.30%, Potassium 0.03 - 0.22%, Magnesium 0,01 - 0.04%, Zinc 0.01 - 0.03%, Iron 0.02 - 0.12%, Copper 0.001 - 0.012%, Nickel 0.01 - 0.043%, Cobalt 0.006 - 0.02%.

Computations based on the wet weight of the complete (whole) goat skin gives values as shown in Table 4.12 below. The figures show that an average goat skin of 1.40kg weight

SERIAL No OF GOAT SKIN	MEAN ASH WEIGHT (g)	MINERAL CONTENT								
		Ca (g)	Na (g)	K (g)	Mg (g)	Zn (g)	Fe (g)	Cu (g)	Ni (g)	Co (g)
1	1.52	0.0256	0.1055	0.0592	0.0111	0.0102	0.0392	0.0078	0.0108	0.0063
2	1.87	0.0611	0.1634	0.1160	0.0233	0.0172	0.1067	0.0056		
3	1.84	0.0776	0.1980	0.1176	0.0269	0.0311	0.0846	0.0048		
4	1.38	0.0534	0.1598	0.0619	0.0198	0.0216	0.1161	0.0064		
5	2.28	0.0536	0.2176	0.0693	0.0199	0.0252	0.0741	0.0053		
6	2.02	0.0878	0.1444	0.0741	0.0190	0.0226	0.0825	0.0063		
7	1.29	0.0294	0.1098	0.0741	0.0131	0.0106	0.0413	0.0060		
8	2.03	0.0500	0.2706	0.2203	0.0363	0.0242	0.1050	0.0060	0.0426	0.0170
9	1.34	0.0375	0.0739	0.0549	0.0163	0.0172	0.0282	0.0058		
10	1.57	0.0364	0.0730	0.0370	0.0143	0.0169	0.0352	0.0068	0.0315	0.0149

TABLE 4.11

Ash and Mineral on content of 100 g fresh goat skin

Serial no of Goat Skin	Mean Ash Weight (g)	MINERAL CONTENT								
		Ca (g)	Na (g)	K (g)	Mg (g)	Zn (g)	Fe (g)	Cu (g)	Mi (g)	Co (g)
Range*	1.29	0.0294	0.0715	0.0370	0.0111	0.0102	0.0282	0.0014	0.0108	0.0063
	2.28	0.0878	0.2706	0.2203	0.0363	0.0311	0.1161	0.0118	0.0426	0.0170
Mean	1.71	0.0516	0.1516	0.0854	0.0200	0.0197	0.0713	0.0068	0.0283	0.0127
S.D.	±0.11	±0.006	±0.0203	±0.02	±0.002	±0.0021	±0.01	±0.0003	±0.009	±0.0023

TABLE 4.11a Cont.

*The upper figures are the lower limits and the lower figures are the upper limits of the Range.

TABLE 4.12

Computed values for ash and mineral . content of goat skin based on wet weight of whole skin.

PARAMETER	RANGE	MEAN
Live Weight (g)	14,000 - 26,000	21,800
Weight of whole skin (g)	956 - 1825	1403.7100
Ash Content	13.1600- 35.1300	24.1650
Calcium (g)	0.3691- 1.2618	0.7201
Sodium (g)	0.7274- 3.3528	2.1211
Potassium (g)	0.4973- 2.6653	1.2304
Magnesium (g)	0.1605- 0.4392	0.2747
Zinc (g)	0.1693- 0.4924	0.2714
Iron (g)	0.2776- 1.5035	0.9734
Copper (g)	0.0571- 0.0905	0.0855
Nickel (g)	0.1890- 0.3759	0.3759
Cobalt (g)	0.1098- 0.2053	0.1715

TABLE 4.13

Total mean weight of mineral detected in 10.00 g skin samples from various regions of the Goat.

Selected Skin Portion	Mean ash Weight	Total mean weight of mineral detected in 10g portions of the goat
Neck	0.129 g.	0.003 g.
Chest	0.128 g.	0.003 g.
Anterior Shank	0.201 g.	0.004 g.
Belly	0.111 g.	0.002 g.
Mammary area	0.176 g.	0.003 g.
Posterior Shank	0.182 g.	0.005 g.
Butt	0.145 g.	0.012 g.
Back-bone	0.209 g.	0.005 g.
Front Butt	0.186 g.	0.004 g.
Tail	0.210 g.	0.009 g.

Selected Portion of Goat Skin	Ash from 100 g Selected portion (g)	MINERAL CONTENT								
		Ca (g)	Na (g)	K (g)	Mg (g)	Zn (g)	Fe (g)	Cu (g)	Ni (g)	Co (g)
Neck	1.29	0.0359	0.0934	0.0355	0.0114	0.0143	0.0625	0.0038	0.0219	0.0079
Chest	1.28	0.0329	0.0864	0.0788	0.0102	0.0113	0.0520	0.0055	0.0312	0.0068
Anterior Shank	2.01	0.0536	0.1368	0.1047	0.0252	0.0199	0.0936	0.0087	0.0122	0.0068
Belly	1.11	0.0203	0.0840	0.0436	0.0089	0.0096	0.0433	0.0045	0.0133	0.0078
Mammary area	1.76	0.0360	0.1155	0.0883	0.0145	0.0132	0.0410	0.0058	0.0137	0.0074
Posterior Shank	1.82	0.0501	0.1796	0.0817	0.0234	0.0171	0.0738	0.0031	0.0365	0.0140
Butt	1.45	0.0510	0.9214	0.0351	0.0127	0.0131	0.0429	0.0046	0.0251	0.0189
Back-bone	2.09	0.0702	0.1410	0.0768	0.0200	0.0154	0,0680	0,0074	0.0380	0.0189
Front Butt	1.86	0.0310	0.1216	0.1356	0.0162	0.0162	0.0549	0.0043	0.0179	0.0091
Tail	2.10	0.1510	0.3544	0.1795	0.0198	0.0152	0.0626	0.0050	0.0506	0.0200

TABLE 4.14a

Ash and Mineral content of 100 g fresh goat skin taken from different regions of the animal (values were calculated from mean of ten values each).

Selected Portion of Goat Skin	Ash from 100 g Selected Portion. (g) Mean	MINERAL CONTENT								
		Ca (g)	Na (g)	K (g)	Mg (g)	Zn (g)	Fe (g)	Cu (g)	Mi (g)	Co (g)
Neck	1.67	0.0456	0.1222	0.0468	0.0160	0.0222	0.0569	0.0040	0.0228	0.0082
Chest	1.5379	0.0643	0.1223	0.0554	0.0150	0.0221	0.0526	0.0060	0.0279	0.0121
Anterior Shank	2.46	0.0608	0.2271	0.1561	0.0350	0.0285	0.0710	0.0105	0.0161	0.0055
Anterior Belly	1.90	0.0505	0.1281	0.0714	0.0170	0.0205	0.0712	0.0078	0.0155	0.0151
Mammary area	1.81	0.0902	0.1556	0.1292	0.0155	0.0176	0.0565	0.0040	0.0058	0.0113
Posterior Shank	2.40	0.0868	0.2608	0.1396	0.0367	0.0259	0.1567	0.0146	0.0846	0.0251
Butt	2.18	0.0580	0.1203	0.0522	0.0165	0.0187	0.0623	0.0054	0.0413	0.0180
Back-bone	2.49	0.0557	0.1652	0.1840	0.0249	0.0346	0.8802	0.0064	0.0320	0.0136
Front Butt	2.15	0.0381	0.1422	0.0725	0.0180	0.0153	0.0572	0.0052	0.0209	0.0100
Tail	2.15	0.0909	0.2323	0.2316	0.0325	0.0219	0.0886	0.0076	0.0273	0.0114

TABLE 4.14b

Ash and Mineral content of 100 g fresh goat skin taken from different regions of the animal (values were calculated from individual original values and not means).

if ashed will give a mean ash weight of 24.00g and a total mineral ion content of 6.224 g (of those mineral element so far determined). The mean weight of the experimental goats is 21.80 kg and the goats ranged in weight between 14.00 and 28.00 kg.

4.5.2 DISTRIBUTION OF THE MINERAL ELEMENTS

The mean mineral ion content of representative regions of the goat skin were estimated and values of the estimates were tabulated in Table 4.13. The table indicates the mean ash and mineral ion content obtainable from 10.00g of skin computed for each region. Thus, 10.00 g of skin sample taken from the neck region of the goat gave a total of 0.0032 g of the mineral elements investigated while giving an ash weight of 0.129 g. The butt with an ash weight of 0.145 g gave a total mean mineral ion content of 0.0125 g. The anterior belly region contained the least amount of mineral elements (the investigated element) with a total mean weight of 0.0026 g of the ions.

If arranged in descending order of magnitude with respect to the total mean weight of mineral element present in the various regions of the goat skin, the following order will be obtained, viz:

Butt > Tail > Posterior shank > Back-bone > Anterior shank > Front Butt > Mammary area > Chest > neck > Belly.

307238

The ash content of 10g of these various portions would be in the order shown below, viz :-

Tail > Back-bone > Anterior shank > Front Butt > Posterior shank > Mammary gree > Butt > Neck > Chest > Belly.

Table 4.14c gives the detailed mean ionic content of the various skin regions in gms.

4.5.3 INTER-RELATIONSHIPS AND CORRELATION

a. Relationship between Mineral content of skin and Total length of Goat (from snout to tip of tail).

Within the limits of experimental error some correlation was found between the mineral content of the goat skin and the total length of the animal. This correlation is shown in figure 22. The coefficient of correlation was found to be 0.5. The relationship is such that the mineral content increases as the animal increases in length. In figure 4.6 the total length was measured in centimetres while the mineral content was evaluated in grams per 100g of wet skin weight.

b. Relationship between the moisture content and the Zinc level in the goat skin.

When the moisture content of the skin was plotted against the zinc ion level in the same skins a negative correlation coefficient was obtained. Though the correlation coefficient had a low value

yet it is interesting enough to note that as the zinc level in the skin decreased the moisture content increased. This result agrees with the findings of Hsu and Anthony (1974) that water content in skin of zinc - deficient rats was significantly higher than that of zinc supplemented pair - fed controls. Fig. 23 shows this relationship. The coefficient of correlation was computed to be -0.4 approximately and the equation relating them is of the form

$$\text{Zinc} = 0.0078 - (0.0874 \times \text{Moisture})$$

Copper ions showed extremely low correlation with the moisture content. Other ions were also uncorrelated.

c. Relationship between the mineral elements found in the goat skin.

Table 4.15 below summarises the measure of correlation between the mineral ions found in the goat skin in terms of their correlation coefficients. It is note worthy that the coefficients of correlation between copper and all other ions are negative except in the case of sodium where the coefficient of correlation is positive. However, only in the case of zinc is the correlation significant at a probability of: $(P < 0.05)$. The relationship between copper and zinc is shown in Fig. 24. The coefficient of correlation, R, is -0.7 approximately and the equation relating these two ions in the goat skin is :-

$$\text{Copper} = 0.0078 - (0.0874 \times \text{Zinc})$$

Between the other ions (paired up) the correlation is positive so that as one increases, the other increases

TABLE 4.15

Correlation coefficients between pairs of Mineral elements in Goat skin.

	Ca	Na	K	Mg	Zn	Fe	Cu
Ca		0.4614	0.2585	0.4819	0.7525**	0.6237	-0.0502
Na	0.4614		0.8066*	0.8690***	0.6947*	0.7581**	0.4928
K	0.2585	0.8066*		0.9160****	0.4163	0.5787	-0.3408
Mg	0.4819	0.8690***	0.9160****		0.7127*	0.7221**	-0.5357
Zn	0.7525**	0.6947*	0.4163	0.7127*		0.5835	-0.6897*
Fe	0.6237	0.7581**	0.5787	0.7221**	0.5835		-0.3626
Cu	-0.0502	0.4928	-0.3408	-0.5357	-0.6897	-0.3626	

Degrees of freedom = 8

* P0.05 = 0.632

** P0.02 = 0.715

*** P0.01 = 0.765

**** P0.001 = 0.872

as well. In the case of copper and zinc, one increases as the other decreases. Those pairs of ions marked with asterisk (*) in Table 4.15 are those correlated at significant levels and the correlation between these pairs are shown in the plots of Figs. 25 - 29

d. Distribution Map of the mineral elements in Goat Skin.

From the sum total of the results of analysis done on the goat skin, a distribution map (Fig. 30) of the mineral elements found in it has been drawn. Fig. 30 shows the regions in which the highest (indicated by the number 1) and the lowest (indicated by the number 2) levels (or concentration) of each element may be found in the goat skin. Generally speaking however, the mineral elements are to some extent found throughout the goat skin. The distribution of some of the elements in the goat skin is quite uneven. The hinder regions and the extremities have higher concentrations than the fore and central parts. The values obtained show wide variations in the individual mineral ion content in the various regions of the skin. These variations are clearly seen in the bar charts of Figs. 13 to 21 . The values used for plotting these charts are drawn from Table 4.14b which values were obtained from computations based on the individual sample values and not on means as in Table 4.14a. The standard error is represented by the vertical line drawn through the mid-point of the top of each bar.

These charts show clearly that calcium is most abundant in the posterior shank, tail and mammary areas

of the skin while it is least abundant in the front butt. The difference in levels of this element in the other regions is not much. Sodium has it's peak also in the posterior shank. The anterior shank and tail rank next while it's level in the other regions does not vary much. Potassium is abundant in the tail, back-bone, anterior shank, posterior shank and mammary areas while less so in the other regions. Magnesium is abundant in the shanks and tail while the other regions seem to have relatively the same level of the element. The zinc level is highest in the back-bone which certains (apart from the tail) longer hair than the other regions. The neck, chest, belly and tail have nearly the same level of zinc. The level of zinc in the shanks lies between that in the back-bone and that in the chest, neck, belly and tail. The level of iron in the posterior shank is the highest. The variation in level in the other regions is minimal. The level of copper in the neck and mammary area is the same while there is a high degree of variation in level in the other regions of the skin. The copper level in the shank skin is the highest. Again the shank skin has more nickel than the other regions while the mammary area contains the least. Nickel levels in these two regions are markedly far apart. The tail, butt, back-bone and posterior shank have cobalt levels that are relatively higher than may be found in other regions of the skin. Relatively speaking cobalt levels in the other regions do not seem to vary much.

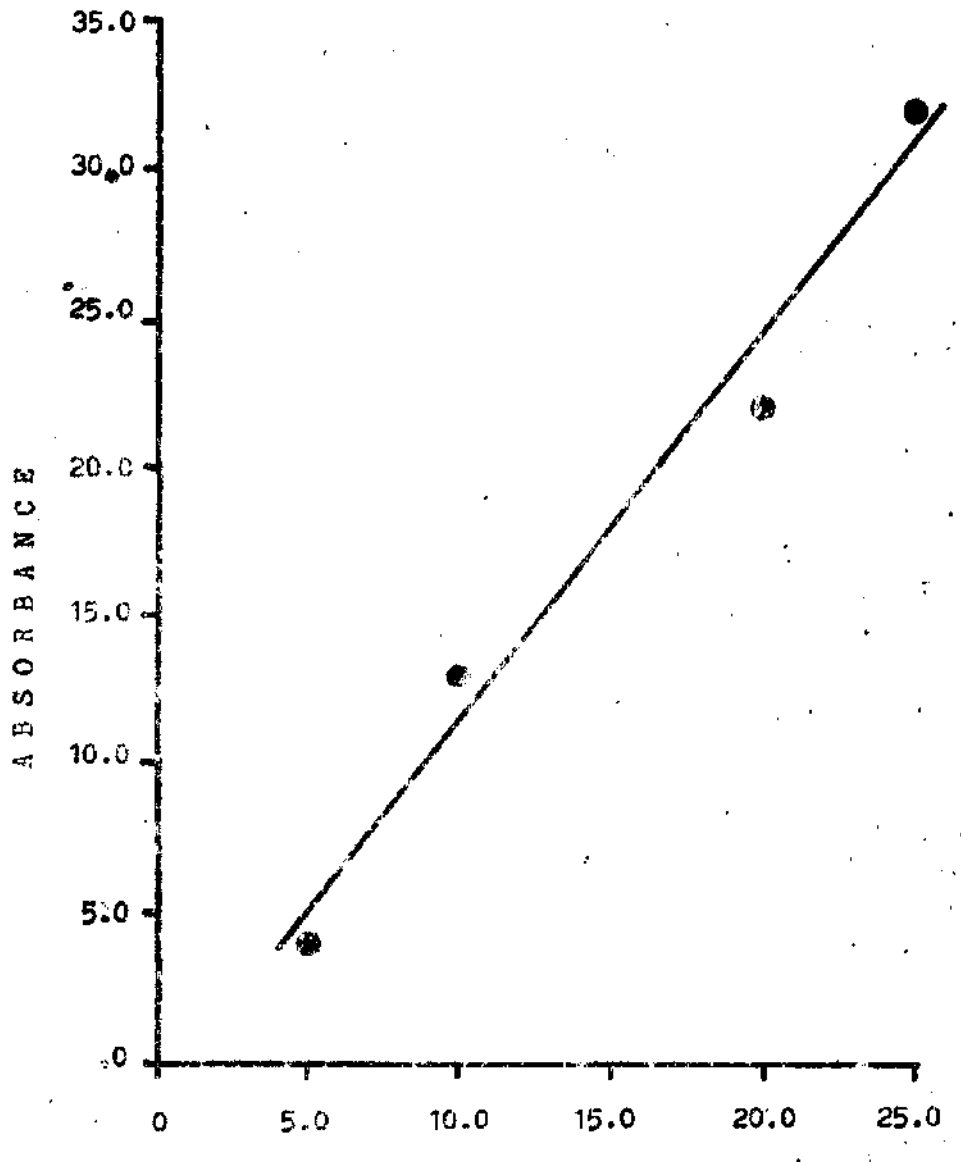


FIG.7 Calibration curve for Calcium.

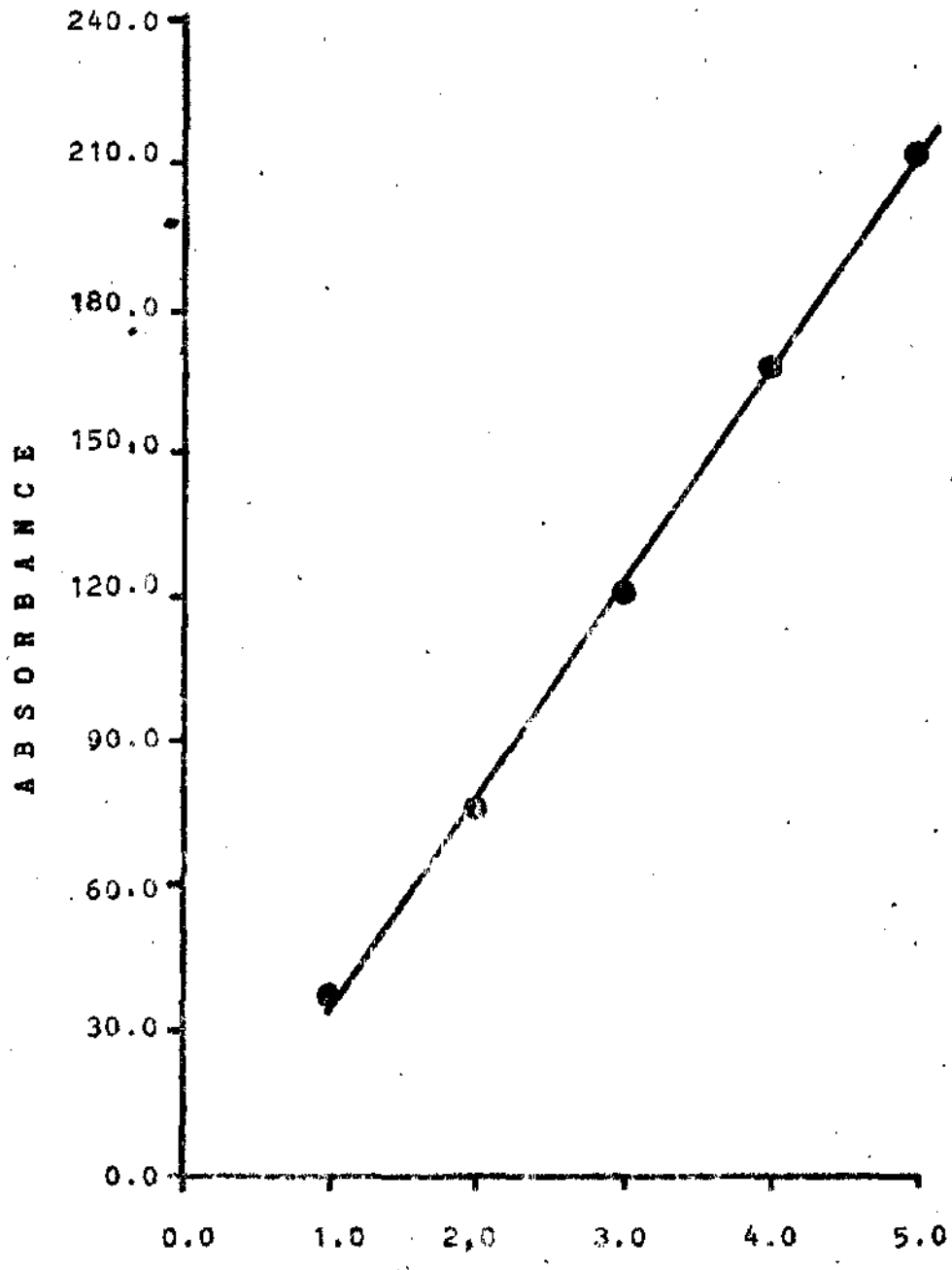


FIG.8. Calibration Curve for Potassium.

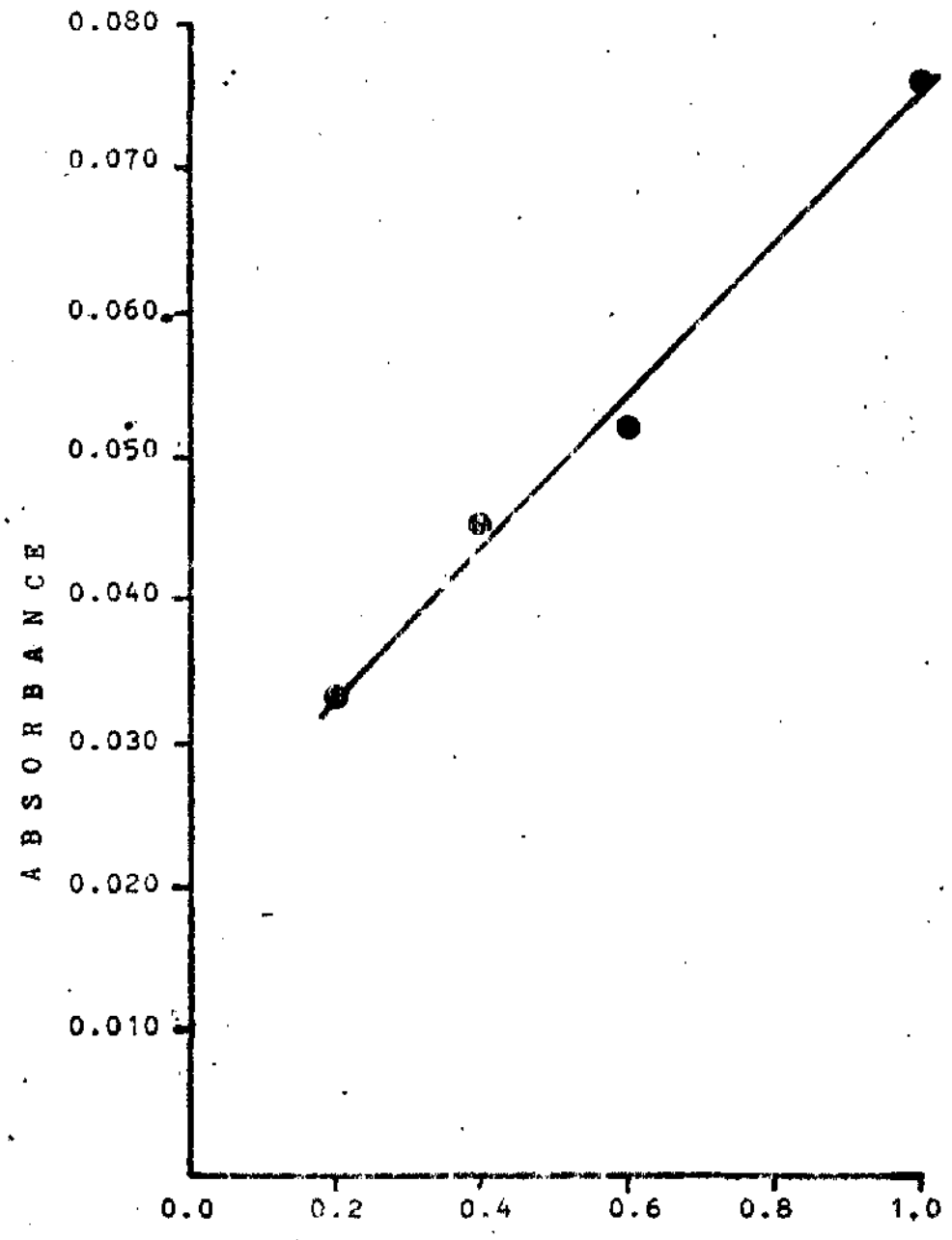


FIG.9. Calbration Curve for Zinc.

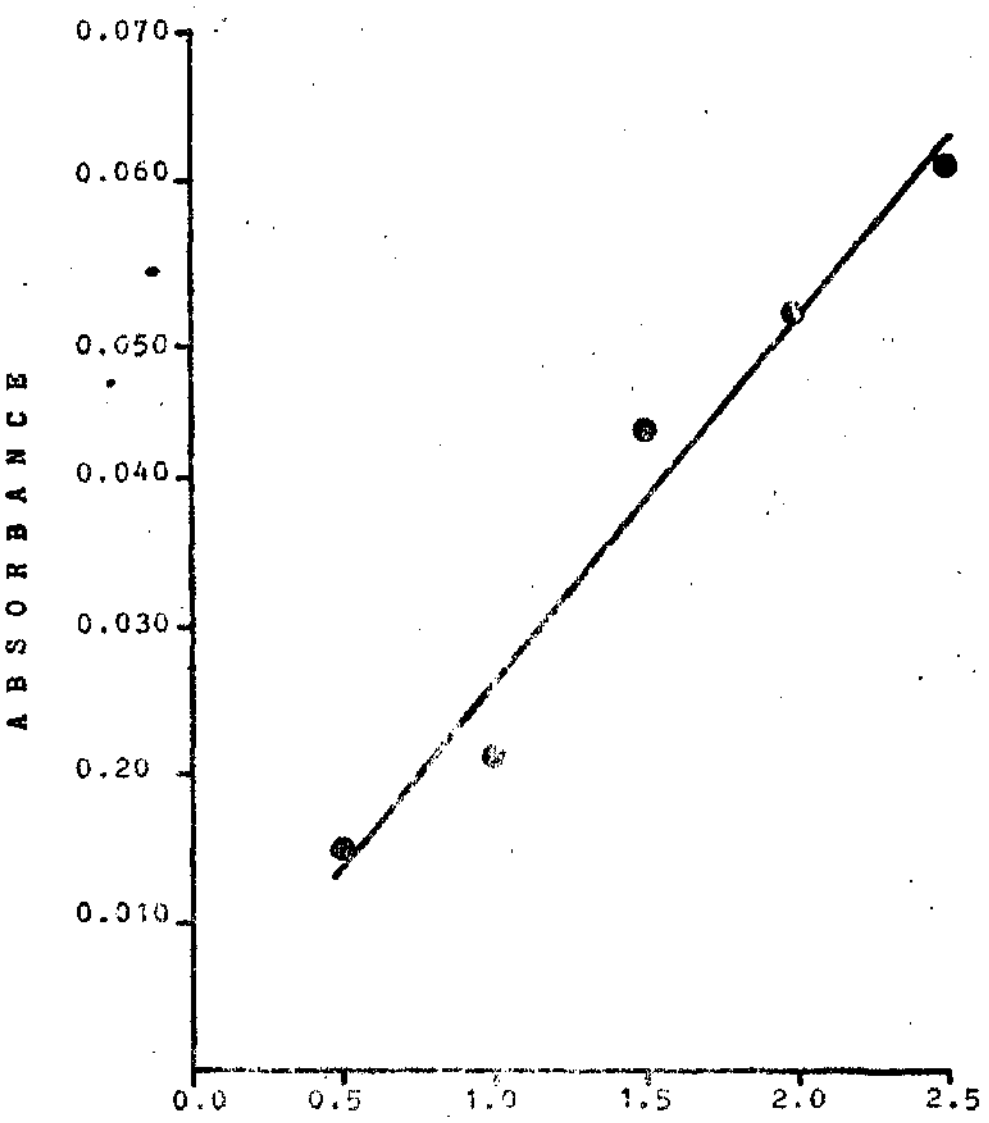


FIG.10. Calibration Curve for Copper.

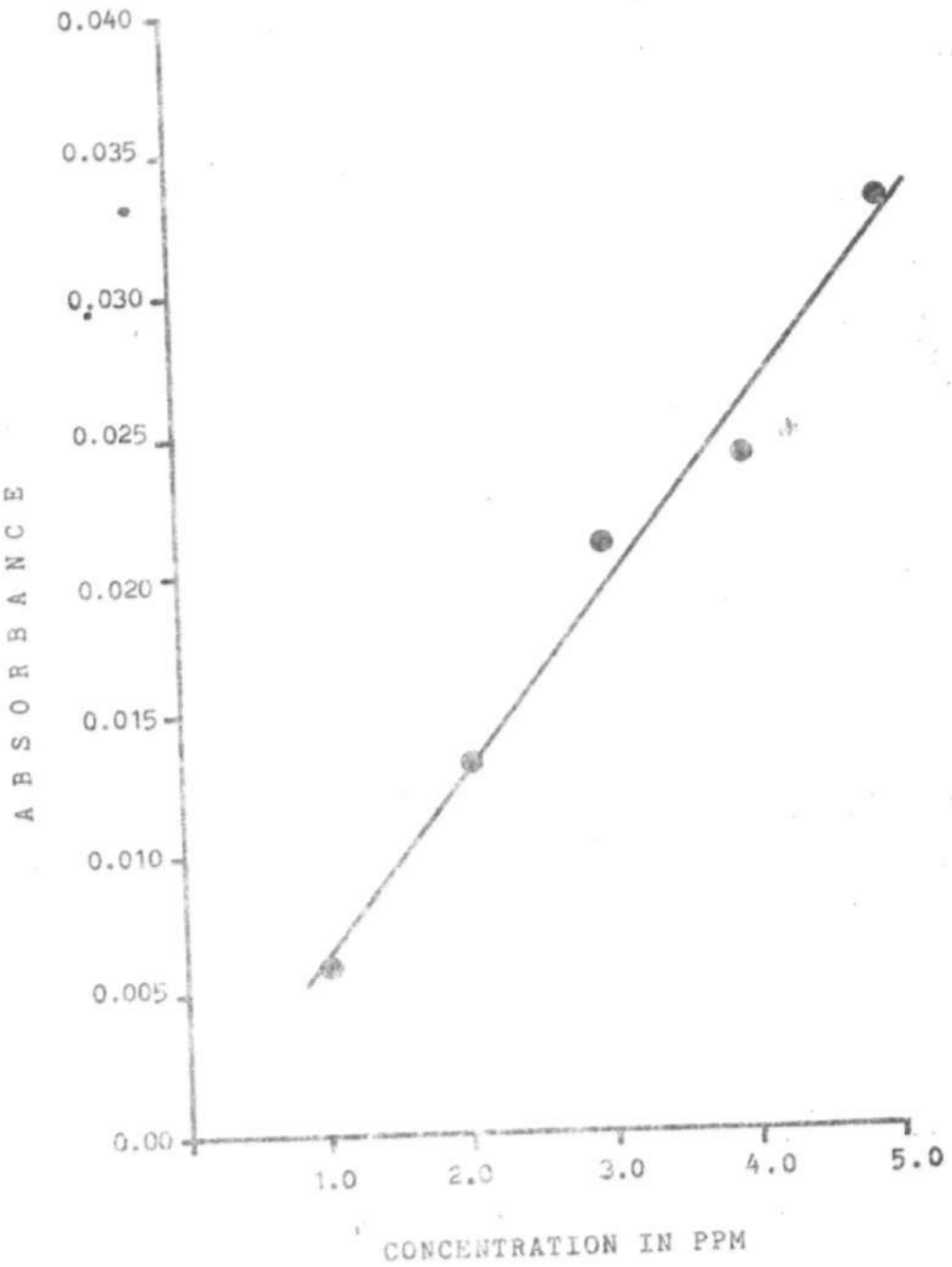


FIG.11. Calibration Curve for Nickel.

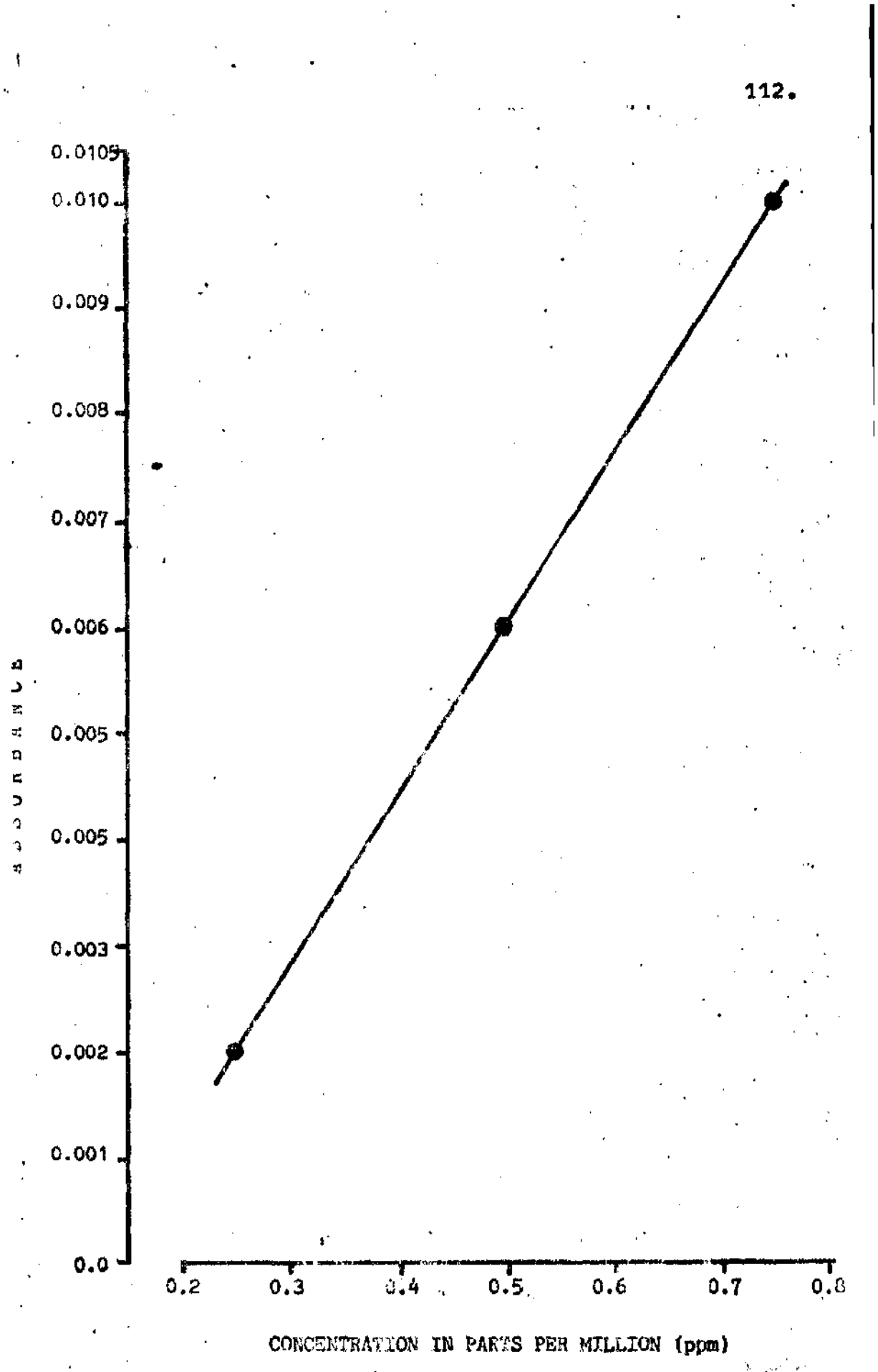


FIG. 12. Calibration Curve for Cobalt.

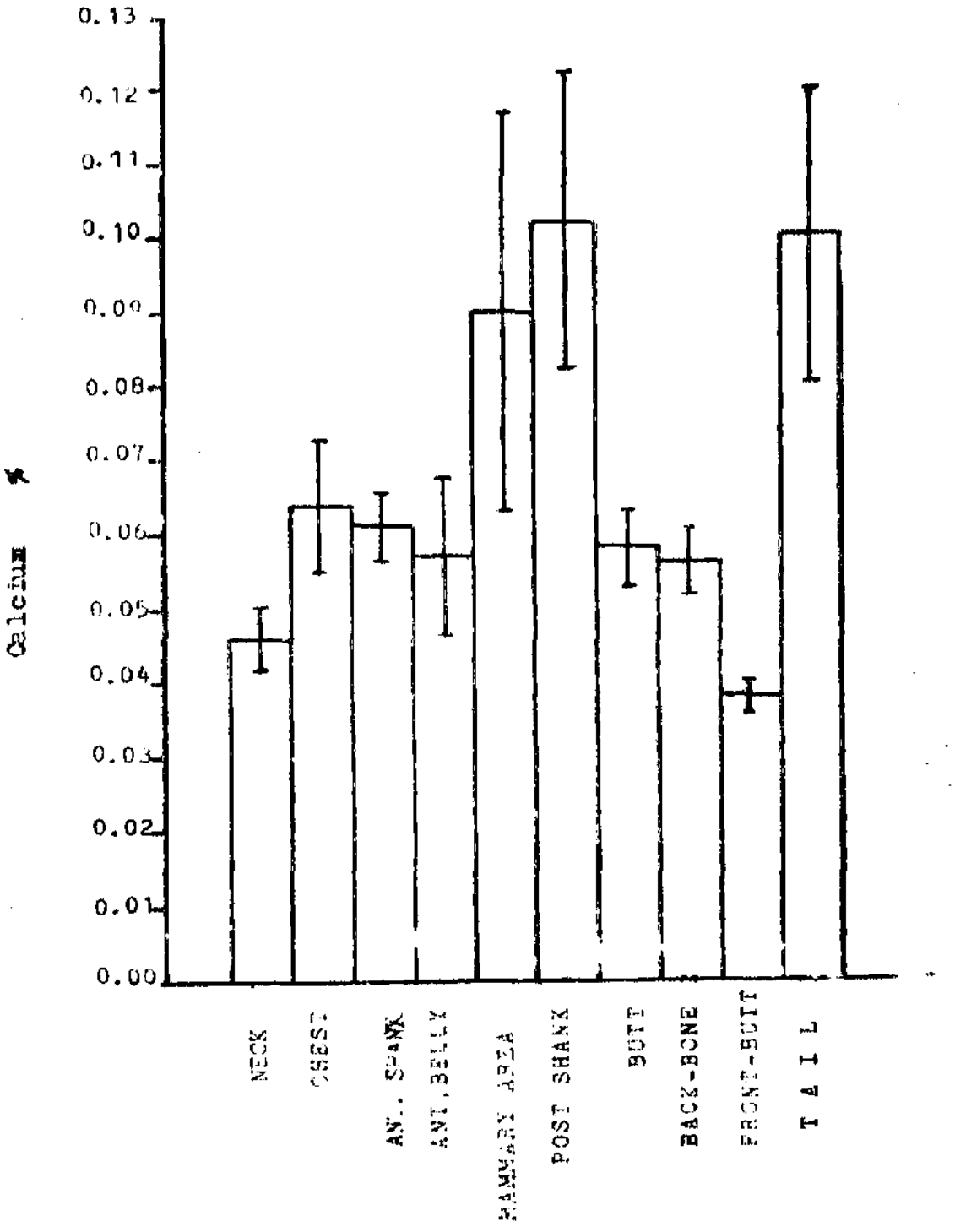


FIG.13 Calcium concentration in different regions of the goat skin.

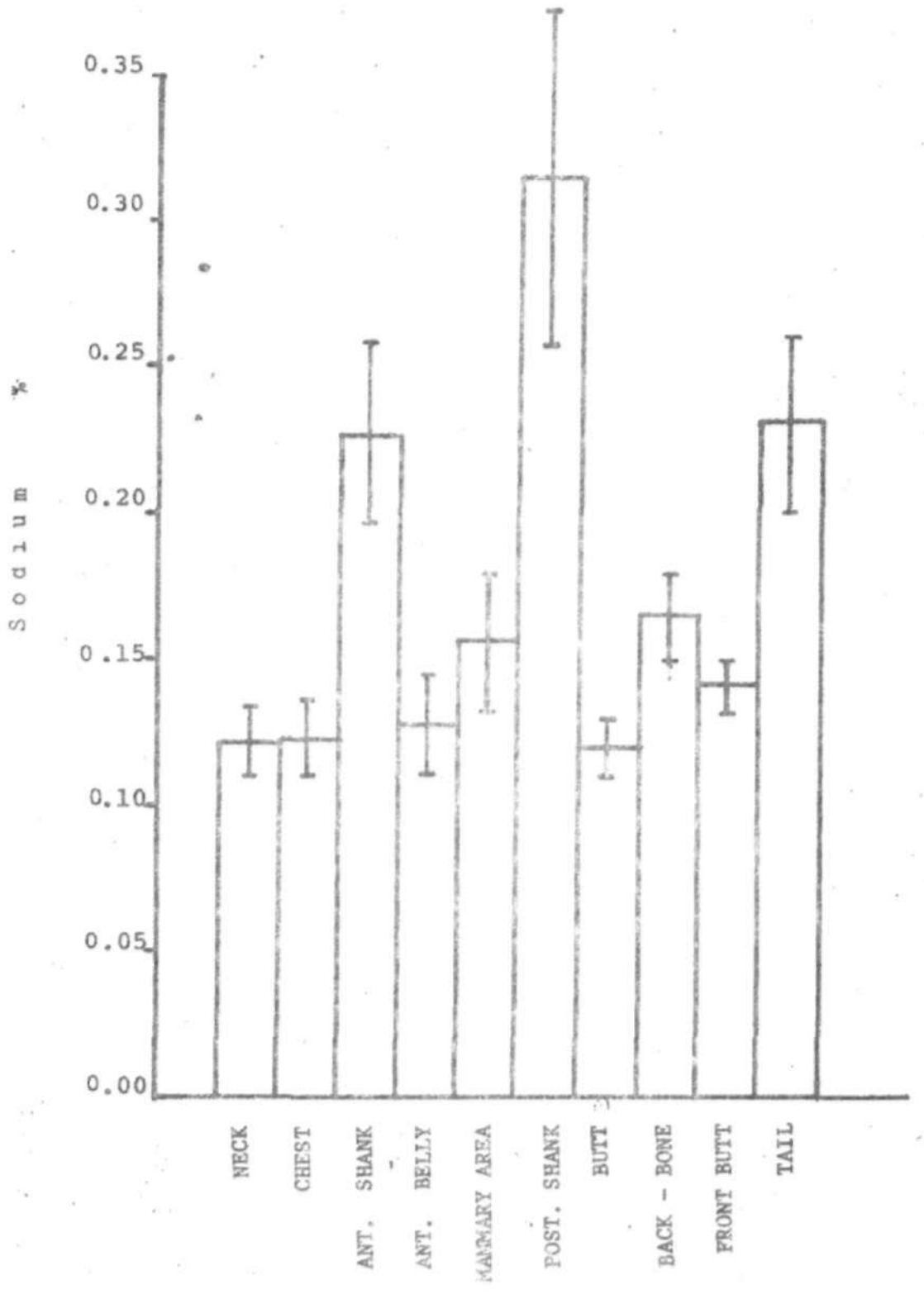


FIG. 14 Sodium concentration in different regions of the goat skin.

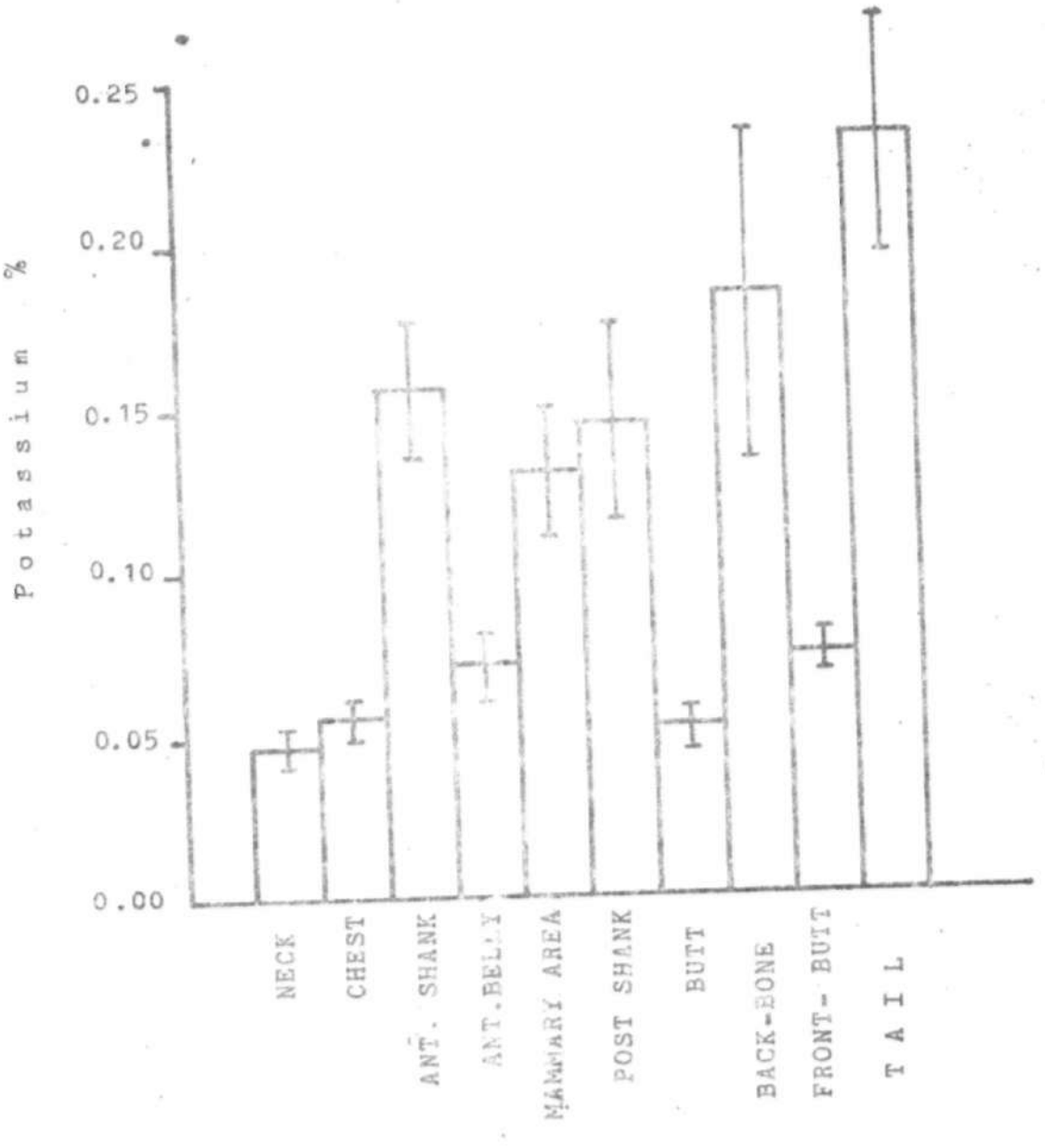


FIG.15 Potassium concentration in different regions of the goat skin.

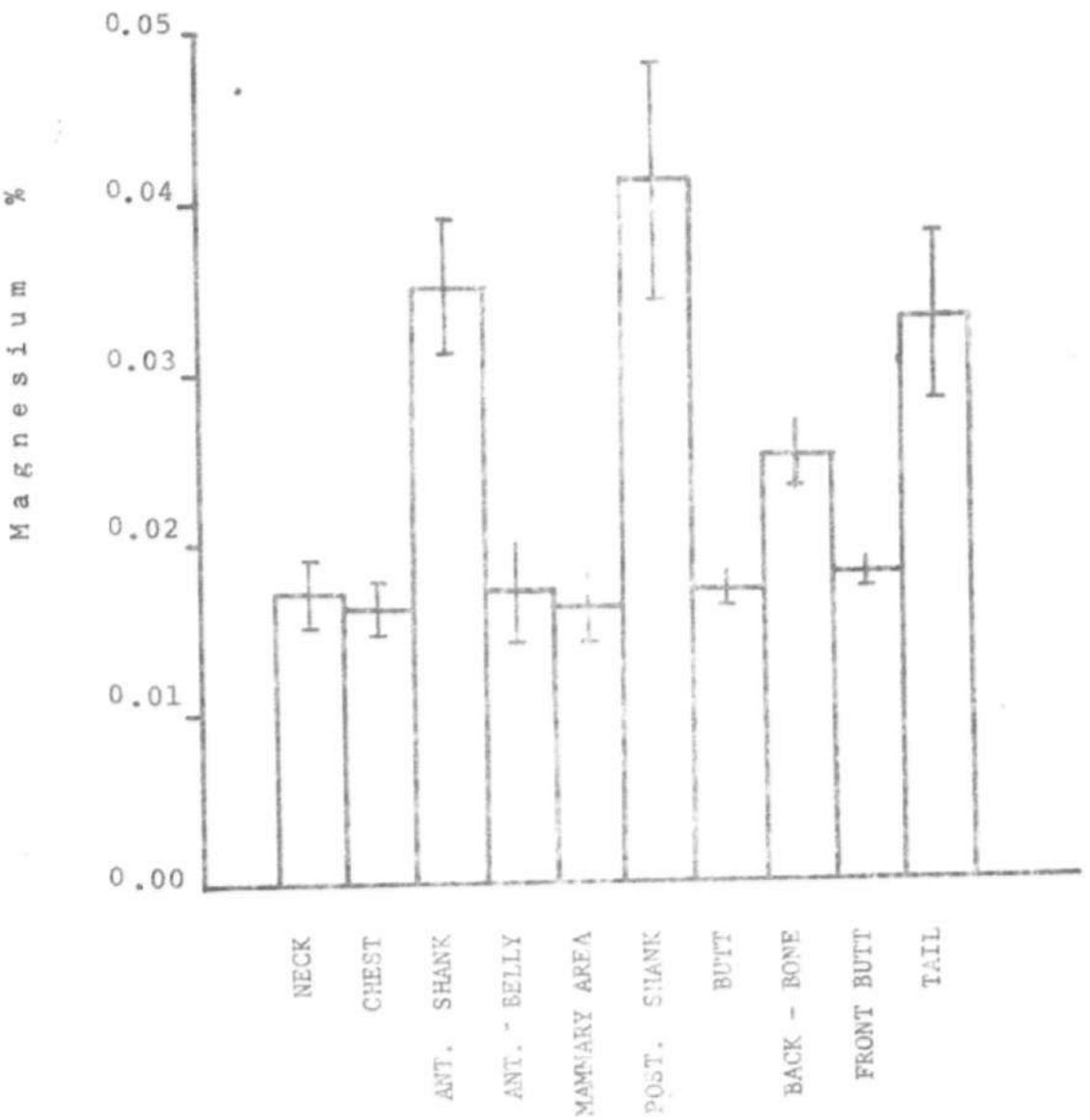


FIG.16 Magnesium concentration in the different regions of the goat skin.

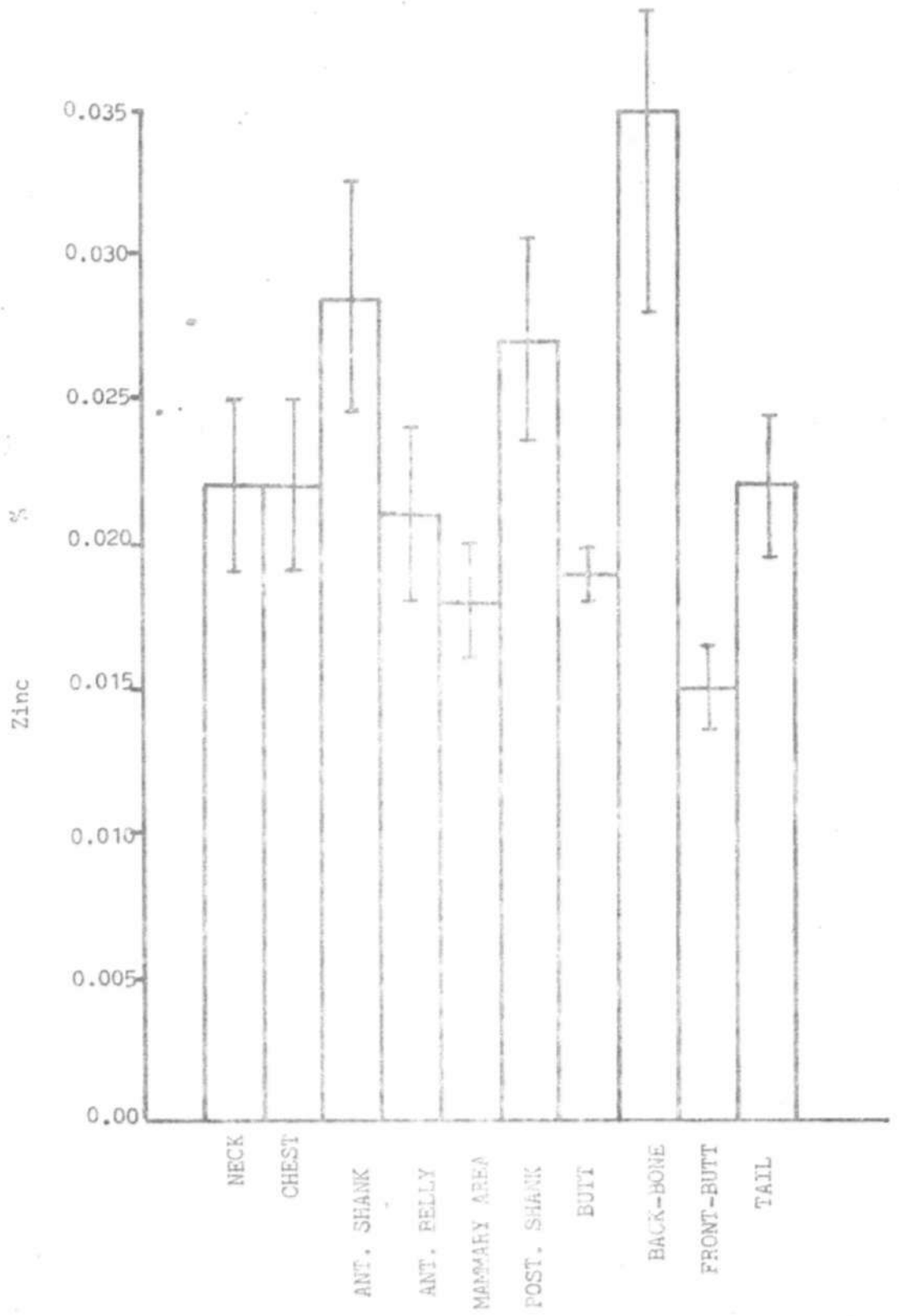


FIG.17 Zinc concentration in the different regions of the goat skin.

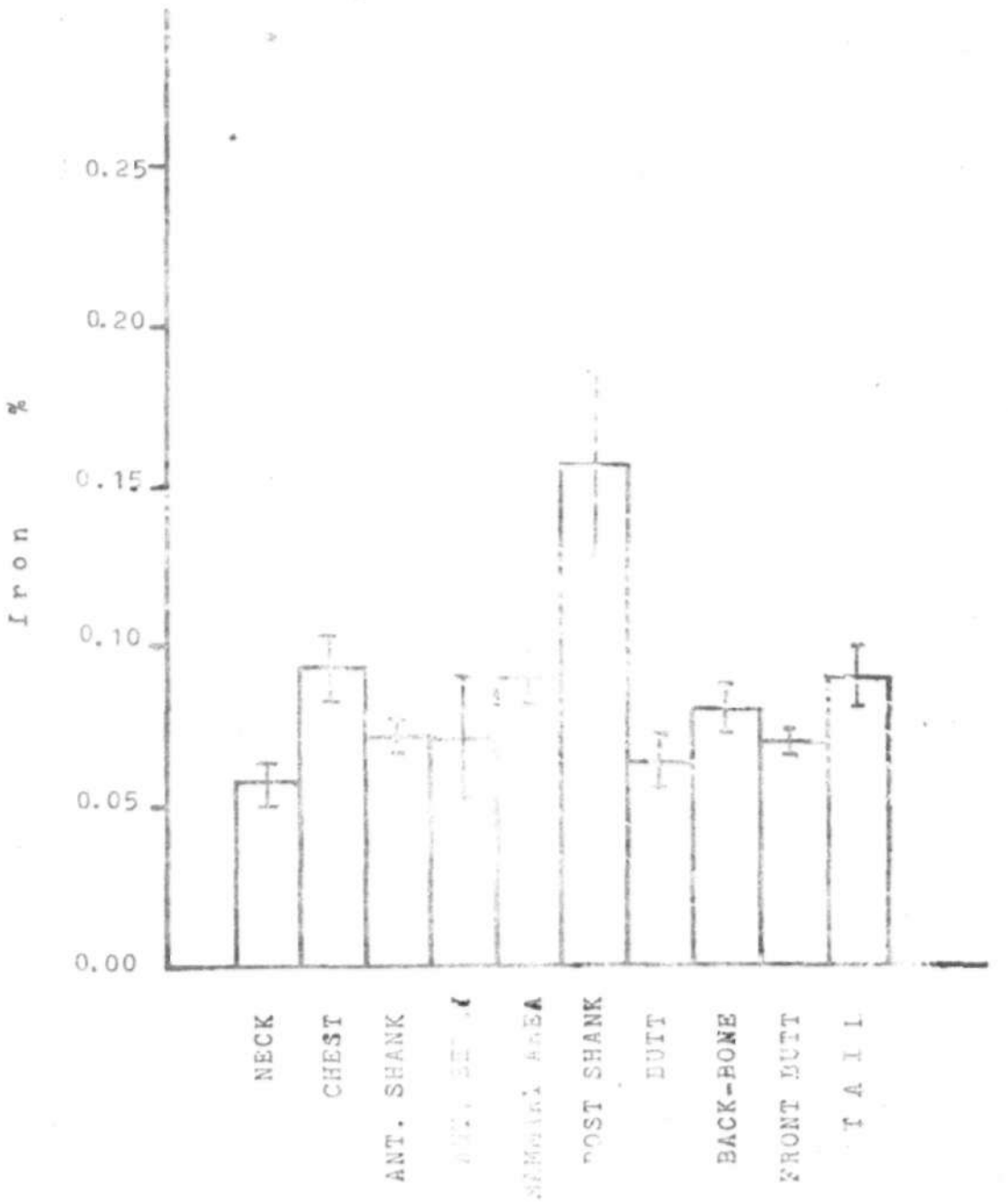


FIG.18 Iron concentration in the different regions of the goat skin.

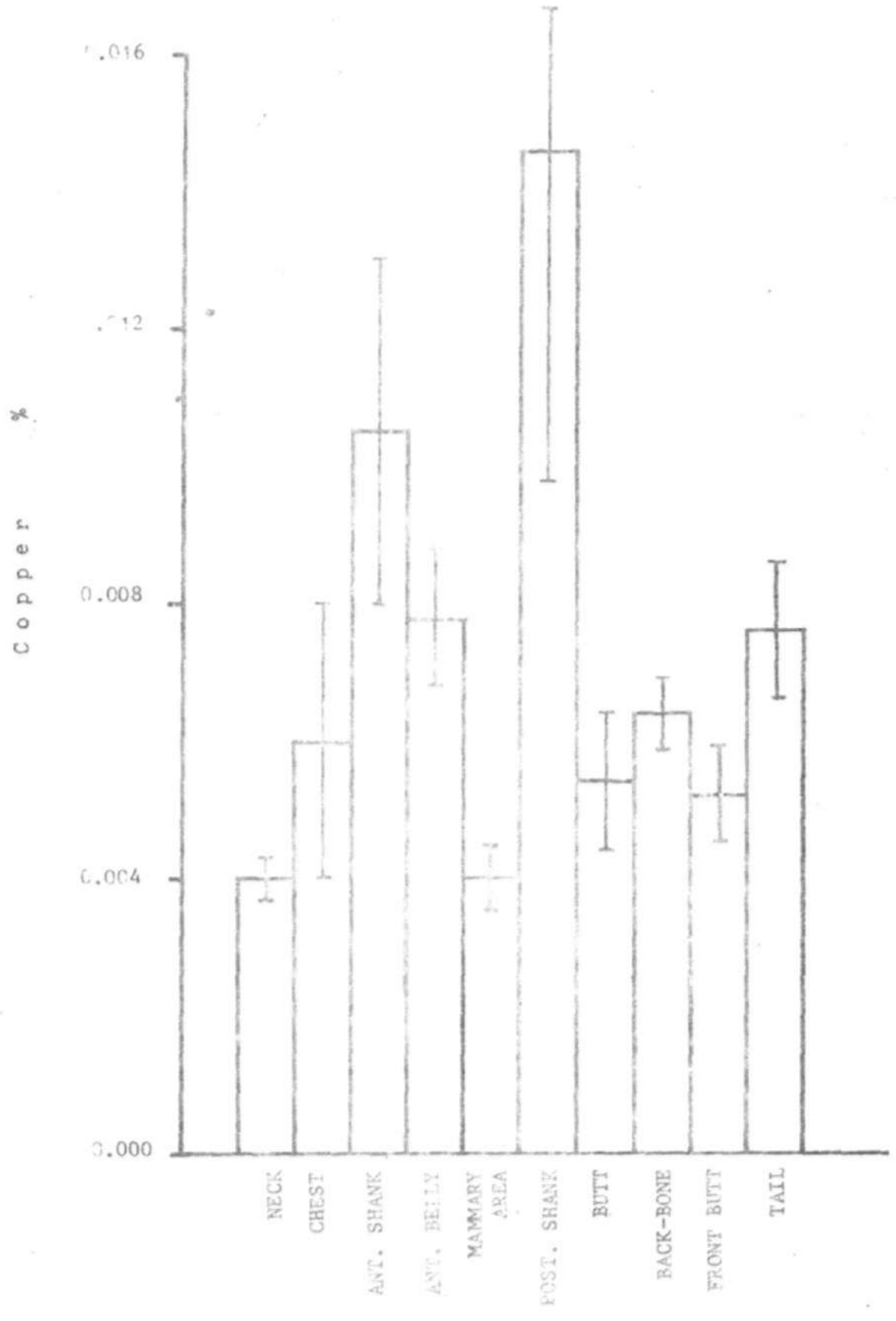


FIG.19 Copper concentration in the different regions of the coat fold.

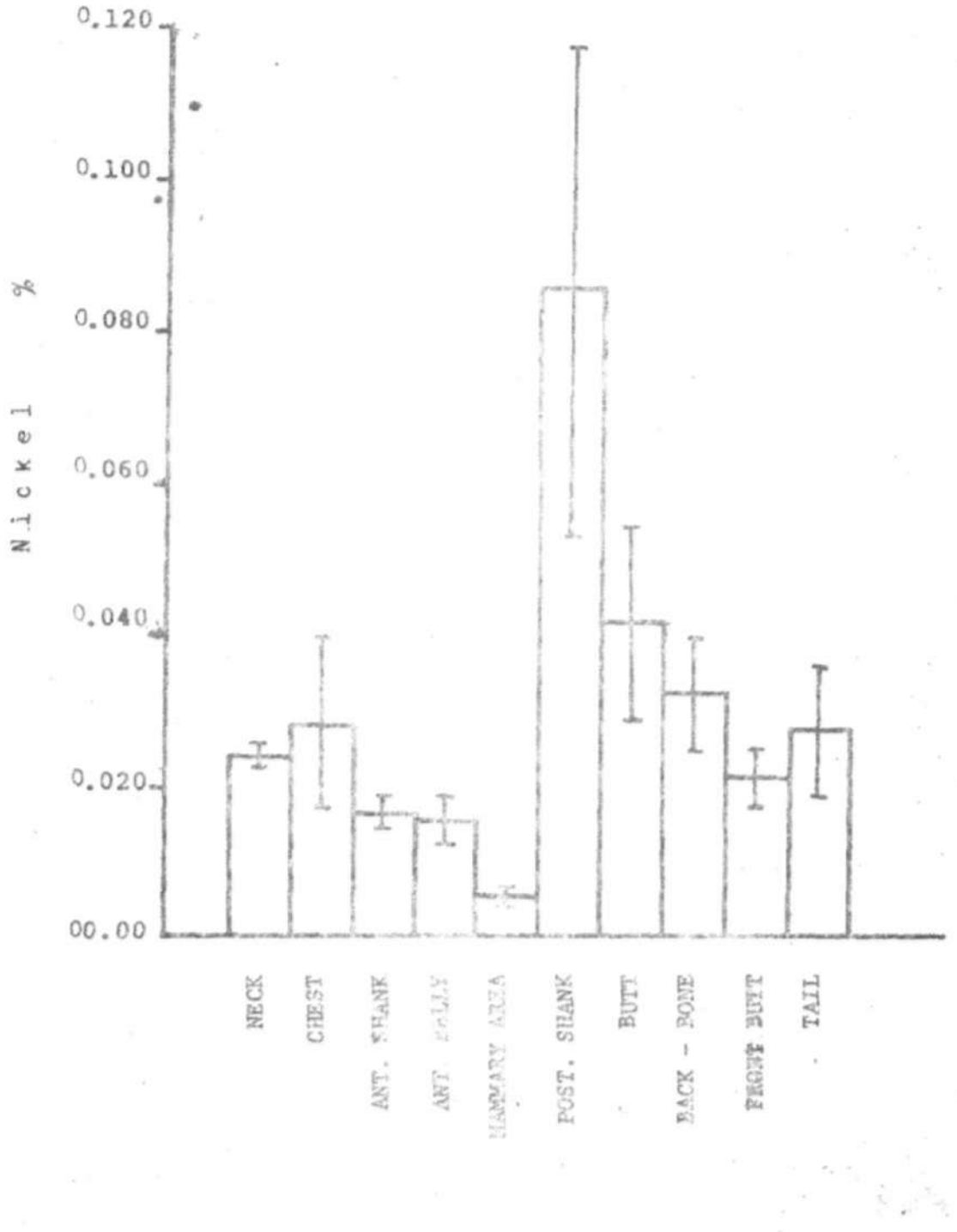


FIG.20. Nickel concentration in different regions of the goat skin

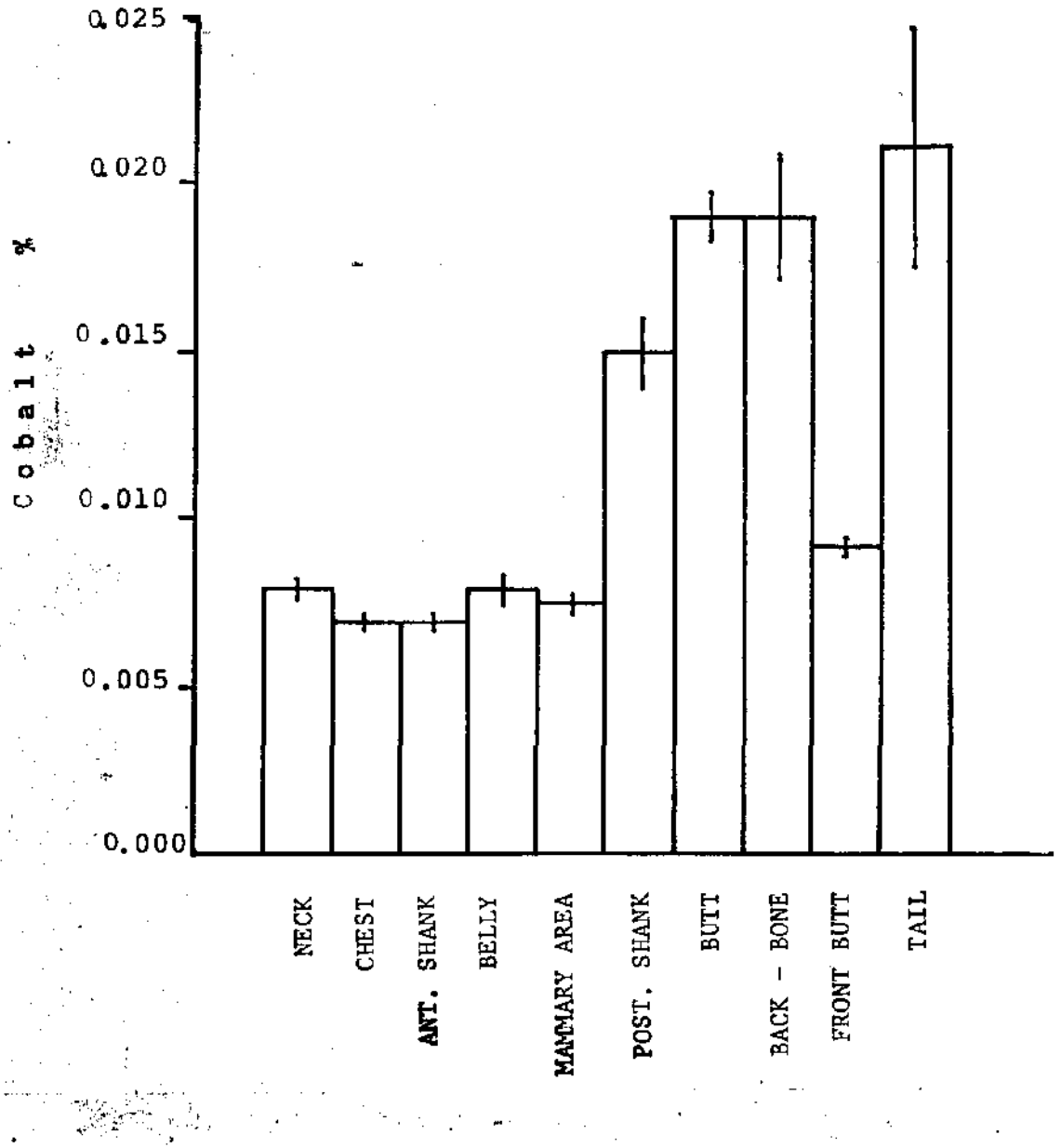


FIG.21 Cobalt concentration in the different regions of the goat skin.

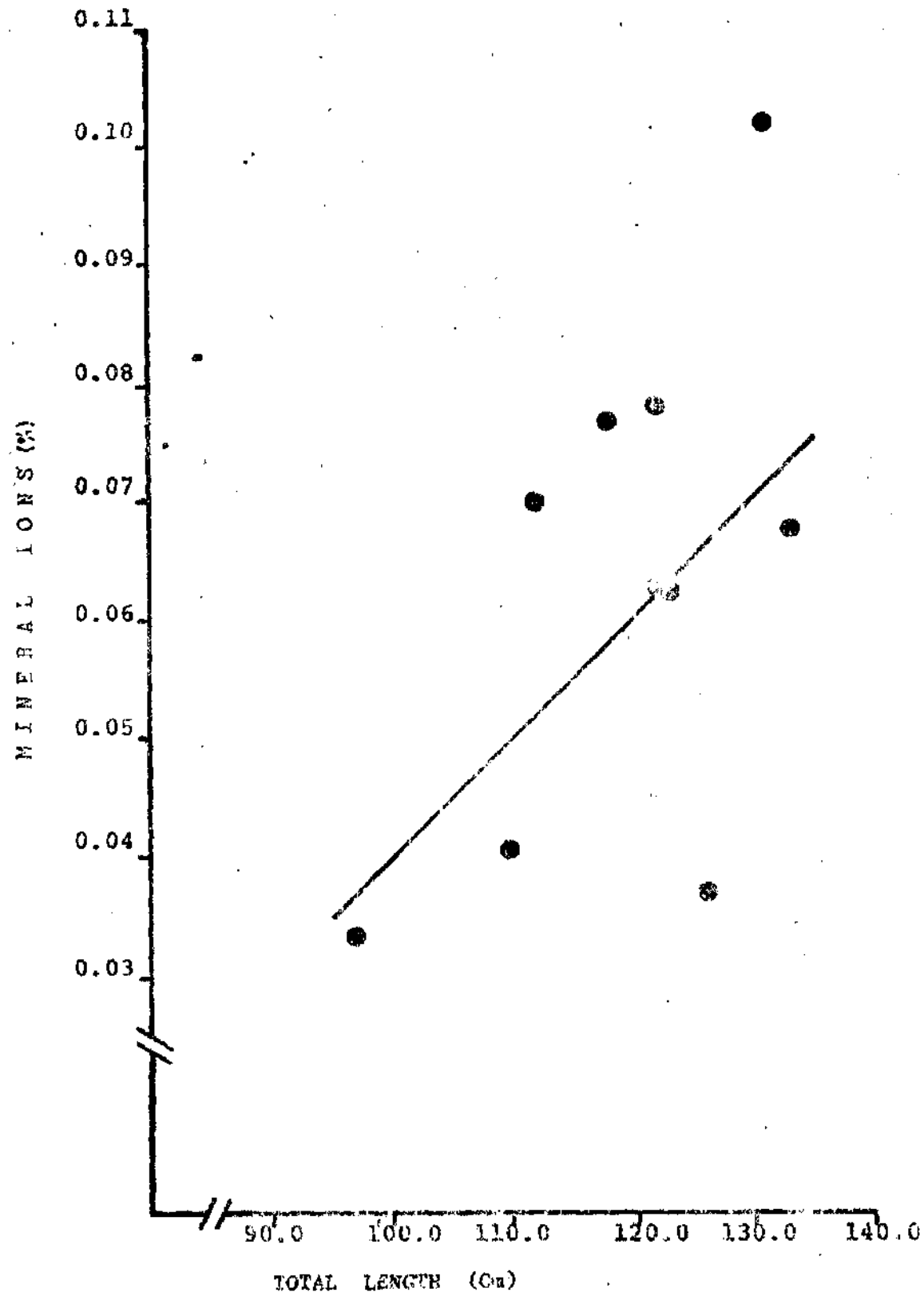


FIG.22 Relationship between the mineral ion content and total length of goat. This is not significant at $P < 0.05$

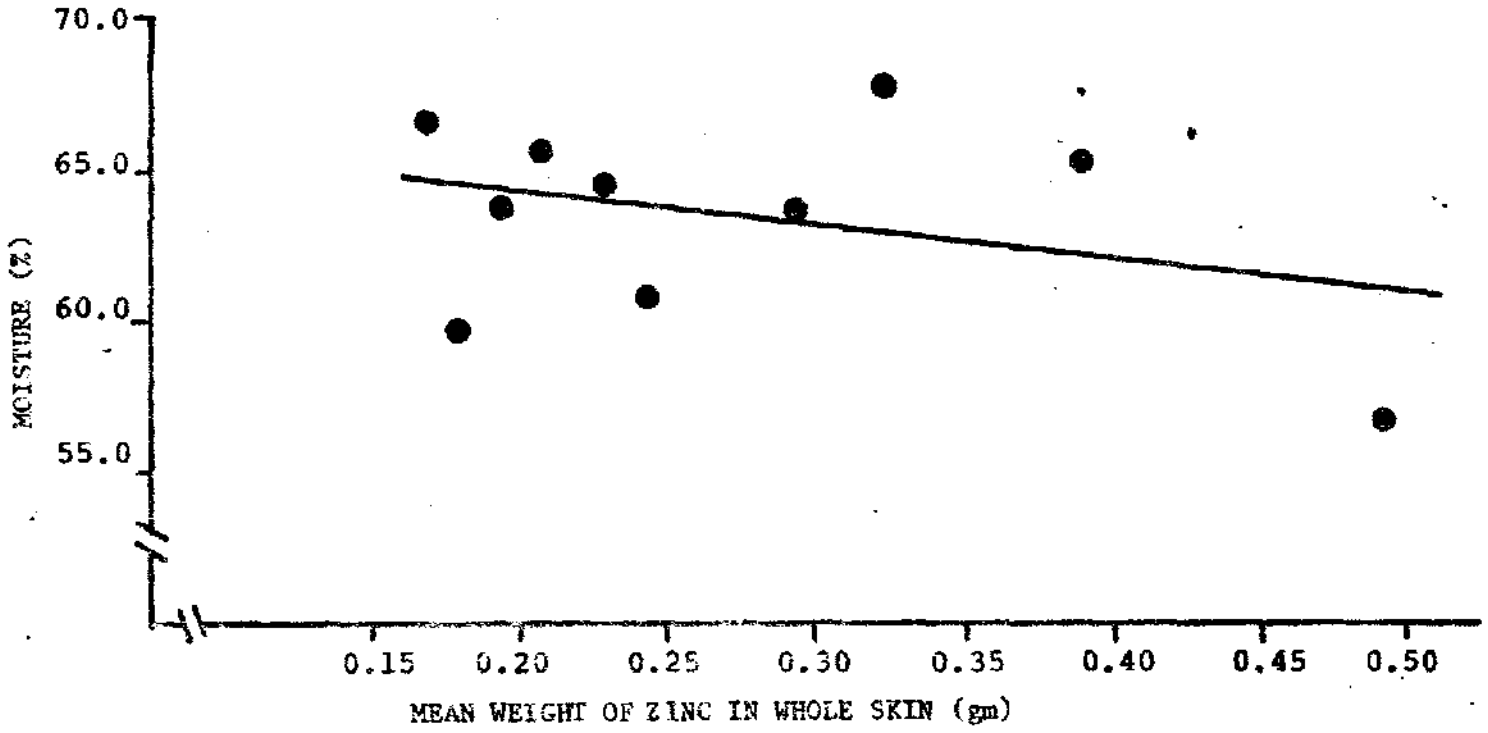


FIG. 23. Relationship between moisture and zinc levels in fresh goat skin though not significant at $P < 0.05$, is negative in such a way that as one increase the other decreases. The correlation coeficient, R, is -0.4.

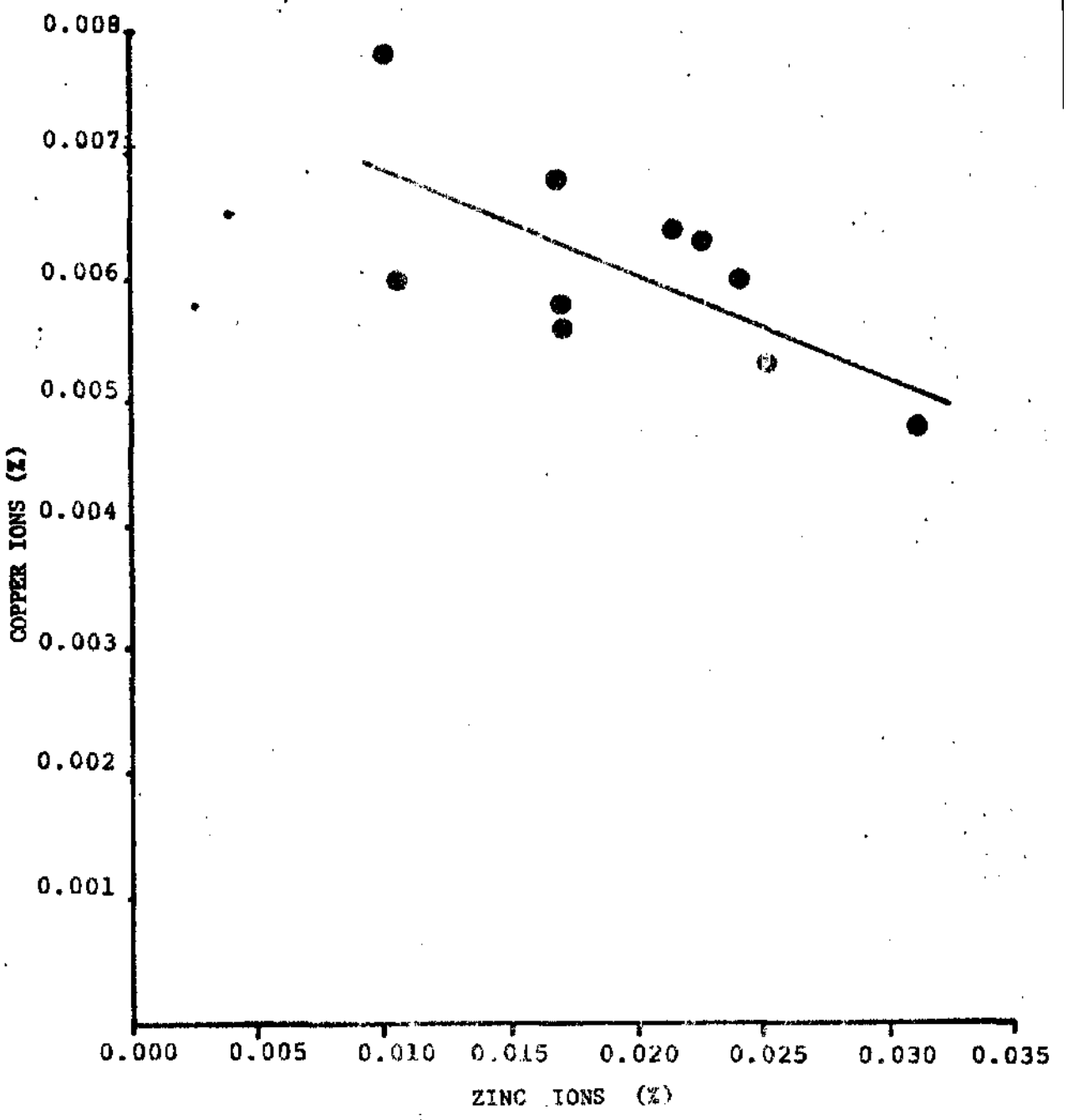


FIG. 24. The relationship between Zinc and copper ions is inverse and significant at $P < 0.05$. The equation linking these two ions in the goat skin is Cu = 0.0078 - 0.0874 Zn and the coeficient of correlation, R, is - 0.69.

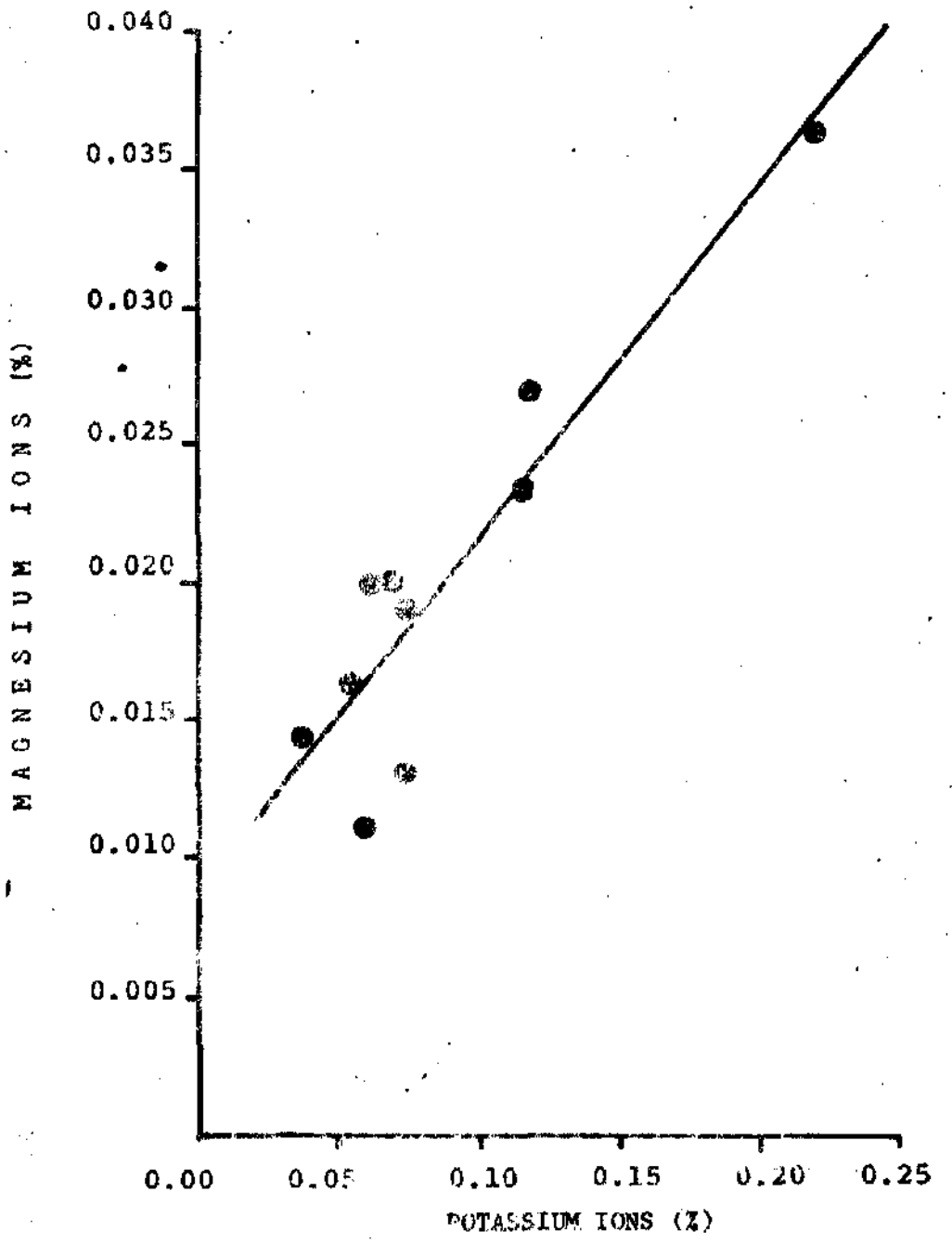


FIG.25 Relationship between potassium and magnesium ions in the goat skin. The relationship is direct and significant at $P < 0.001$ and the correlation coeficient is 0.92.

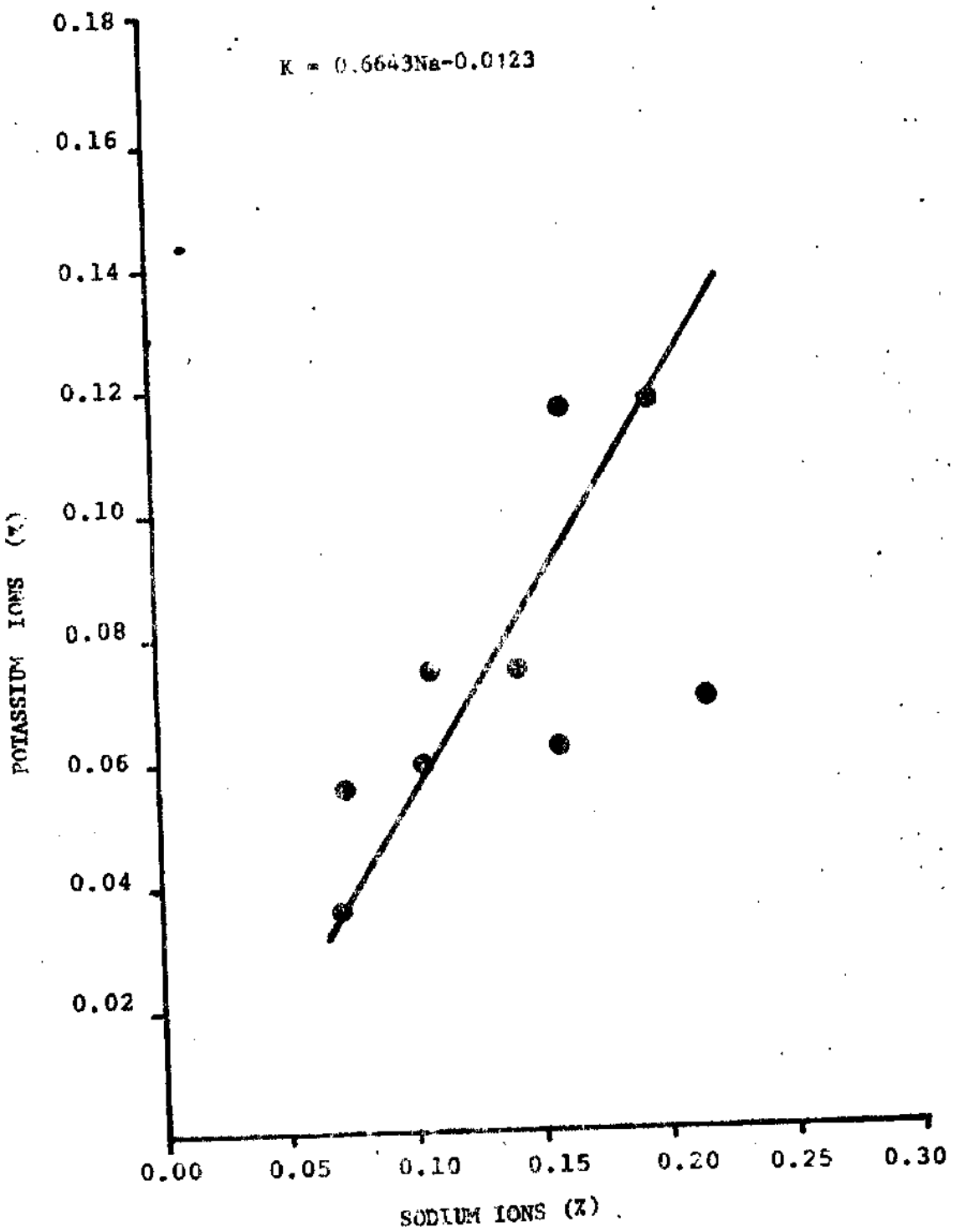


FIG. 26. Sodium and Potassium ions in the fresh goat skin are directly related and have a coeficient of correlation R = 0.81. The relationship is significant at P < 0.01

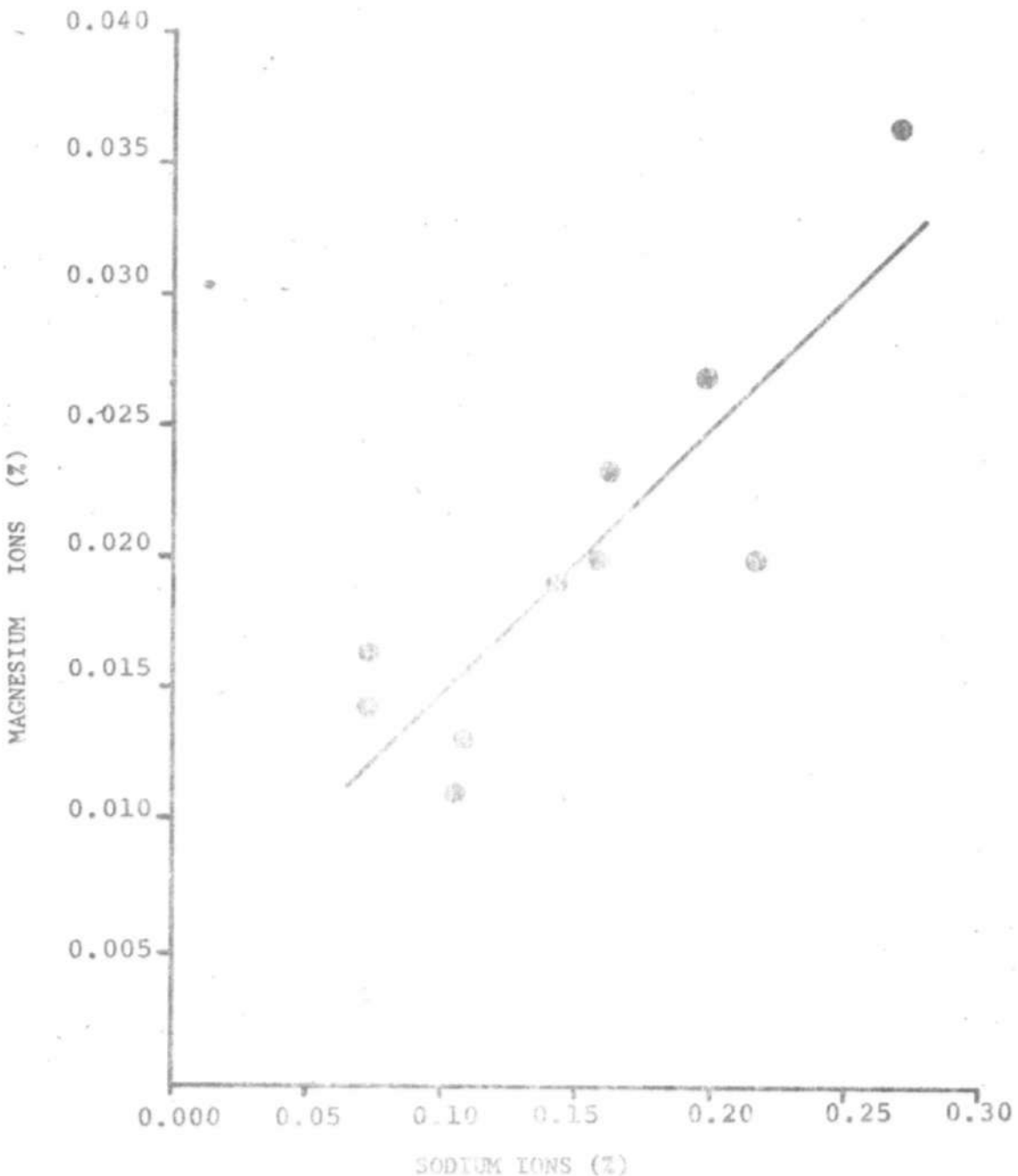


FIG. 27. The relationship between sodium and magnesium is significant at $p < 0.01$. The correlation coeficient is 0.87 and the equation showing this relationship is $Mg = 0.1008.Na + 0.004$

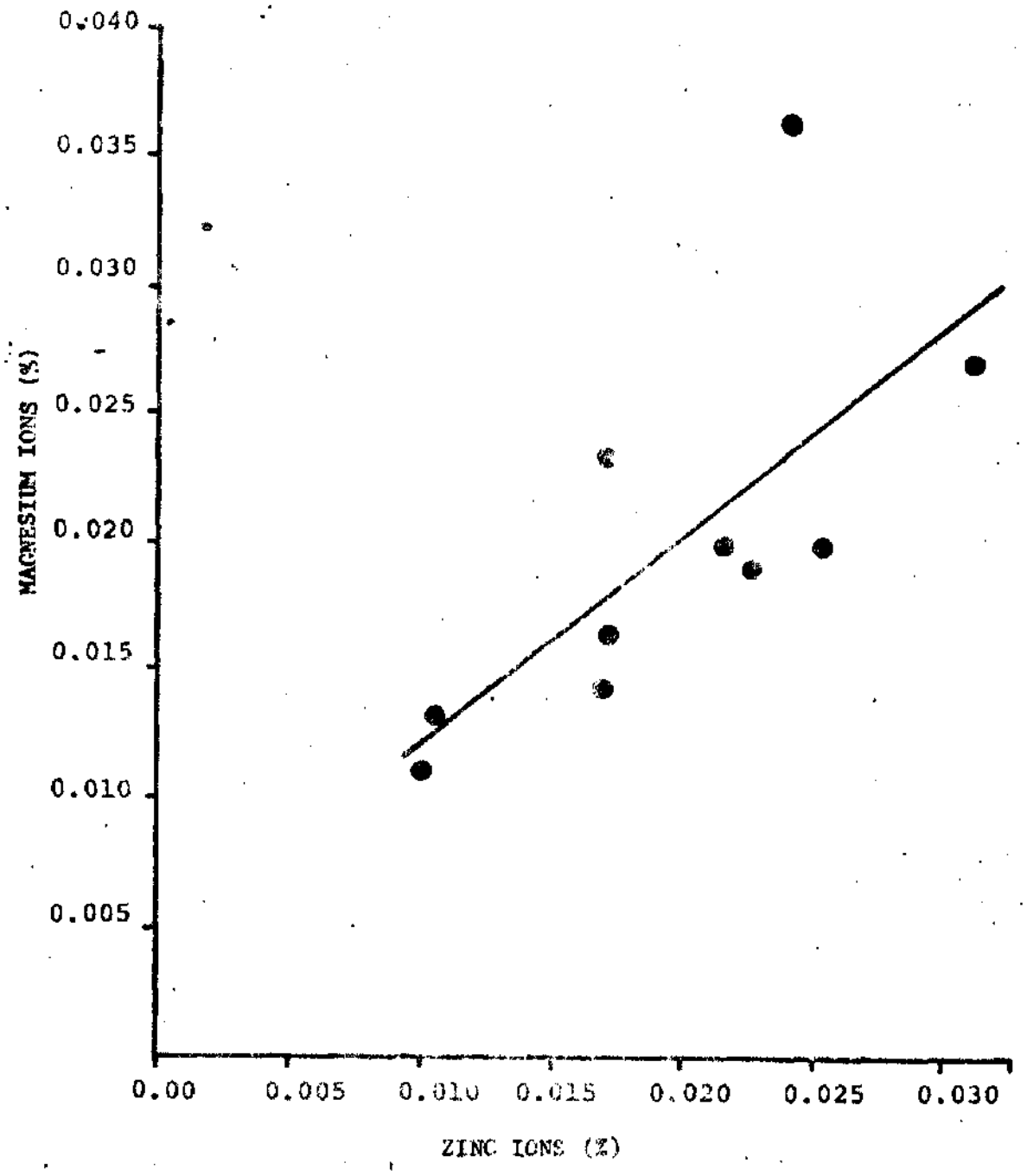


FIG. 28. Relationship between Zinc and magnesium ions in the goat skin. It is direct and significant at $p < 0.2$ with a correlation coeficient, $R = 0.71$.

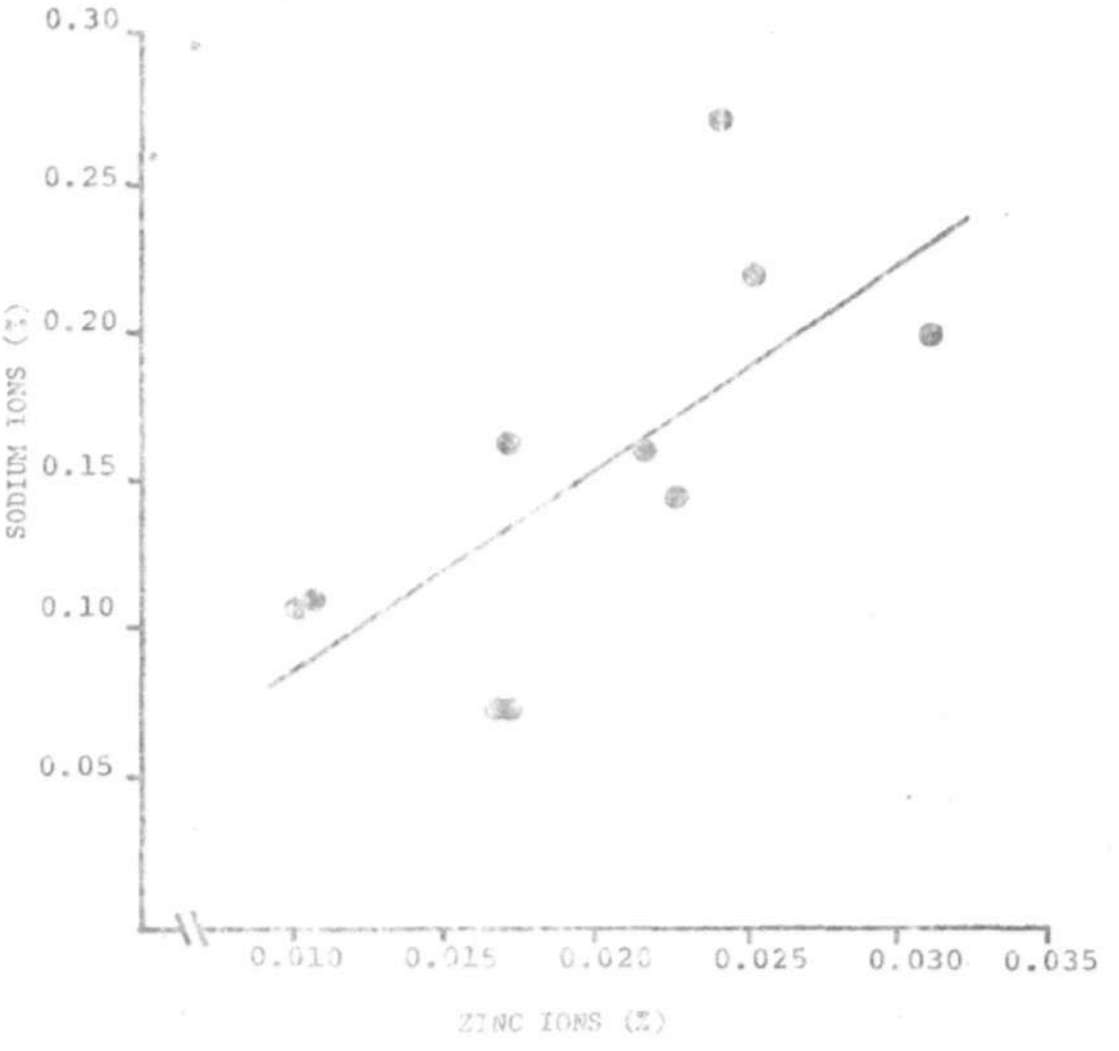


FIG.29. The direct relationship between Zinc and Sodium ions in the goat skin is significant at $p < 0.05$ with a correlation coefficient of 0.70.

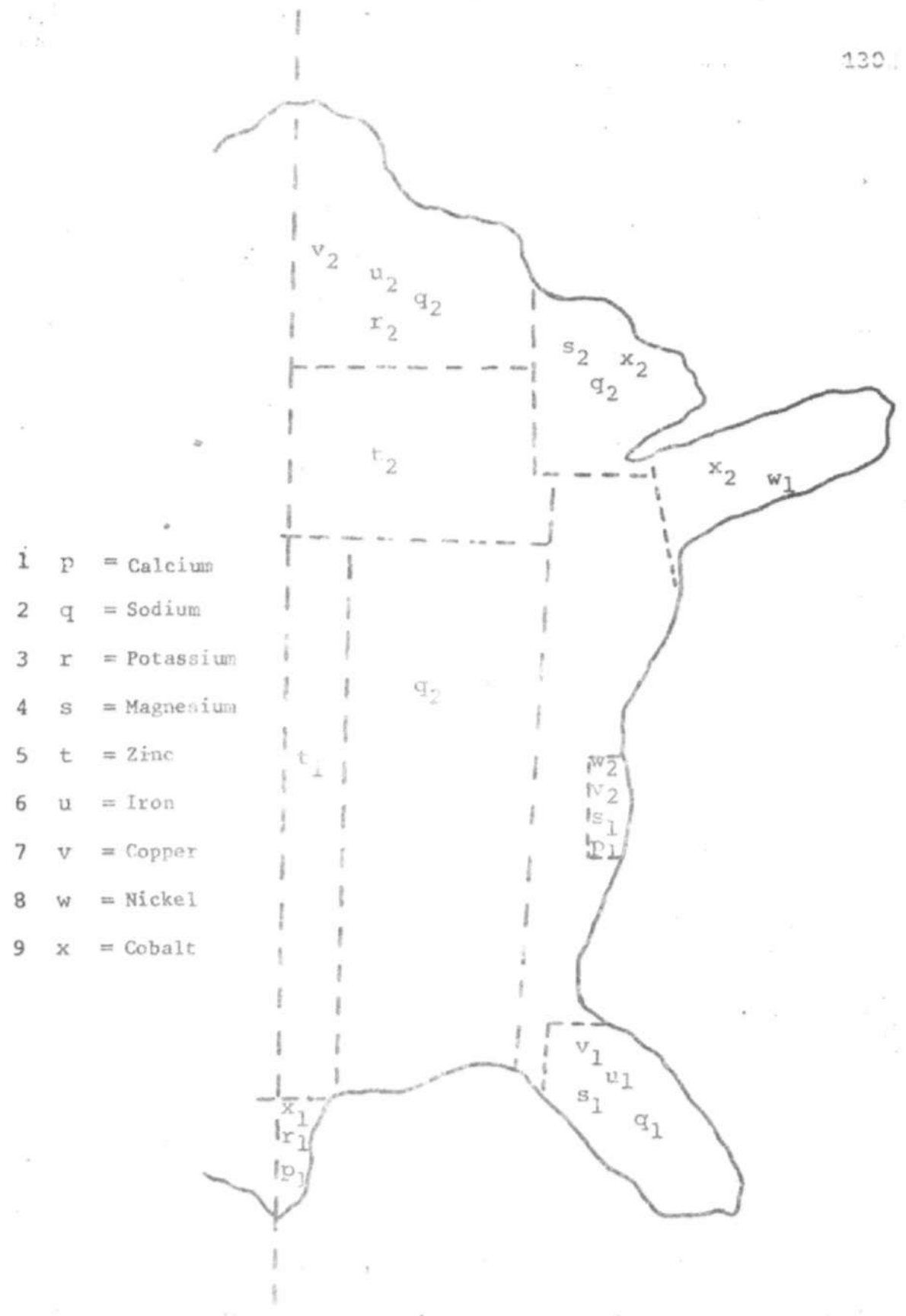


FIG.30 The Distribution Map of Mineral Elements in the Goat Skin. Regions of highest level of concentration are indicated by the number,1, while those of lowest level of concentration are indicated by the number,2.

CHAPTER FIVE

5.0.0 DISCUSSION

5.1.0 General

It is note worthy that, generally speaking, the Guinea Savannah goats of Northern Nigeria are light to dark brown in colour. Occasionally dark coloured breeds may be found amongst these goats and these breeds may have been brought into the Guinea Savannah from other areas of the country or some times from neighbouring Niger Republic.

The brown colour of the goats may be adaptive in the sense that it matches the brownish Savannah soil and the brownish dry season vegetation of their environment. Furthermore, the goats are not quickly seen particularly when they move around the brown mud walls of huts in the villages where they are reared. Thus, they easily escape notice when they constitute themselves into a manace to human food items such as grains and other farm produce that come within their reach.

In general out look the Guinea Savannah goats may be described as 'slender' bodied and weather beaten. They may pass for what Devendra and Burns (1970) described as being in the 'middle range' or 'class' when their size is compared to that of goats from other lands. They are neither tall nor dwarfish. Devendra and Burns (1970) placed goats of about 80-90cm height (at withers) and about 40-50kg weight at the upper range

eg. the beetal goats of Punjab (India), while the dwarf goats of South West African with withers height of about 30 - 40 cm and body weight of about 18 - 20 kg weight are placed in the small or lower range. The Guinea Savannah goats have heights comparable to the Sokoto or Maradi red goats which Devendra and Burns (1970) put at 62-67 cm (at withers) and body weights of 23 - 28 kg. In our work we found the mean body weight of the Guinea Savannah goat to be 22.36 ± 1.48 kg.

5.2.0 PHYSICAL RELATIONSHIPS

5.2.1 Relationship between body weight of the goat and it's total length.

It is to be expected, as the results of the present work confirm, that the weight of an animal will increase as it's total length increases, if other factors, such as health state, nutrition, environmental factors, remain constant. Galeon (1951) in his studies of the external relationships of kids of Philippine goats reported that there was highly significant positive correlation between the body weight (live) and the body length, though no significant correlation was found between the live weight and the height at withers. Results obtained from this study agree with this finding and is confirmed again by the findings of Tandon (1966) who reported highly significant correlations between the logarithm of

the body weight and the logarithm of the total length. The mean body weight of the Guinea Savannah goat is 22.36 kg and it's average length is 1.19 metres.

5.2.2 Body Weight versus wet weight of whole skin.

An animal that increases in weight does so when material has been added to it's body structural frame work. These materials may be added to the body in the form of structural proteins, stored fat or other nutrient molecules such as those of mineral elements and water (Montagna and Parakkal, 1974). For a healthy growing animal it is logical to expect that as the weight of the animal increases through the normal processes of growth it's skin weight will also increase. Fat may be stored as usual in the hypodermis of the skin thus increasing the weight of the skin (Montagna and Parakkal, 1974). The live body weight of the animal is positively and significantly correlated to the weight of the skin at $P < 0.05$. Literature does not indicate that comparisons between live weight and fresh skin weight for goats have been made in the past.

5.2.3 Other Physical Relationships

No significant correlations were found between the wet skin weight and total length; between the body weight and average horn length; between the total length and average horn length. The relationships established between the above

pairs of parameters were positive but not significant.

5.3.0 The Moisture Content of the Goat Skin

The moisture content of the goat skin measured as a percentage of the fresh skin weight ranges between 56% and 68%. The average (mean) moisture content is 63.47% ± 1.07% (moisture content here includes the volatile material of the skin since at the drying temperature of 102 ± 2°C used in the experiment volatile substances and fats are oxidized (SLC - 1966). The range for moisture content of medium sized skins of animals such as sheep, goats, baboons, etc. from many lands is given as 60 - 70% and the mean is generally accepted as 64% approximately (SLC 1965). This Mean is approximately the same as that obtained for the Guinea Savannah goats of Zaria area in this investigation. This mean value approaches the moisture content value given for the eel with a moisture range of 65 - 68% (Spector, 1956). The moisture content range of values for the skin of an adult man is given as 70 -- 75% (fat - free tissue) (Spector, 1956). Tancous (1955) obtained a moisture content of 63% for fresh hide when he used solvent extraction method for it's determination. In the method, he used benzene as the solvent and the extraction was done in soxhlet flasks. The result obtained by this worker for hide is close to that obtained for the

goat skin (Table 4.5) Sarkar (1964) in his book "Theory and Practice of Leather Manufacture" approximates moisture content to 65% in animal skins - this percentage of course being dependent on species, age, sex, feed, and feeding habits and other habits of the animal.

Result obtained from the experiment on the goat skin show that the moisture content is not uniform throughout the skin as may be glimpsed from the values recorded in Table 4.6. The variation ranges between 57.26% for the tail region and 67.44% for the mammary area.

This variation in moisture content of the different areas of the skin may be explained by the structural variation that exists in the various regions of the skin. From work done in the Central Leather Research Institute in Madras, India, and recorded in the 1963 monograph (Part I) of "Indian Hides and Skins Histological characteristics" (Nayudama, 1963), the structural differences found for the Indian goat skins are as shown in Table 5.1.

The Monograph indicates that the epidermis covers approximately 1.0% to 2.6% of the total thickness of the skin and "is relatively thicker at the neck and back-bone. Hairs are not equally numerous in all locations of the goat skin, _____" (Nayudama, 1963). The grain layer usually occupies approximately 24% to 54% of the total

TABLE 5.1

Grain layer thickness and hair numbers of different regions of the goat skin

Area of Skin	Number of hairs per cm^2	Grain layer thickness as percentage of total skin thickness
Butt	9,500	24 - 40%
Back-bone	9,000	26 - 54%
Neck	7,500	32 - 54%
Belly	6,000	27 - 45%

thickness of the skin. A dense net-work of elastic fibres covers two-thirds of it's grain layer and relatively greater amount are present in the neck and back-bone regions. A considerable amount of elastin is found throughout the corium. The corium proper occupies approximately 45 - 75% of the total thickness while the subcutaneous adipose layer (or flesh) covers roughly 1.0 to 2.0% of the total thickness (Mayudamm, 1963).

It is to be expected that the less dense the net-work of elastic tissues in any area within the skin, the more water that area should be able to hold since the fibrous materials of the skin do not absorb water, as they are water repellent. This fact is also bourne out by the results of the experiment (see tables 4.5 and 4.8) in which it was observed that as the moisture content of the skin increased, the organic content decreased. It is not surprising then that the mammary area, with the least compact mesh of fibrous tissues, should contain the highest percentage of moisture while the tail region with the densest mesh of the fibrous tissues contains the lowest percentage of moisture. Other areas of the skin seem to follow this trend.

Strandine, et al (1951) found that in fresh hide moisture was present in greater quantity in the hair follicle region than elsewhere. It is also known that goat skins are covered with two

types of hair - the short and the long varieties. The short variety is more numerous per square centimetre than the long variety, relatively speaking (Burns, 1955). The short variety covers the mammary area while the long variety covers the tail area. It is therefore to be expected that the mammary area will have a larger number of hair follicles and hence a higher percentage of moisture in it's follicular region than the tail region will have.

5.4.0 <u>The Ash Content and the Organic Matter Content of the Goat Skin</u>.

The handbook of Biological Data (Spector, 1956) gives the percentage ash content for fresh rabbit skin as 0.72%, while that obtained for the Guinea Savannah goat skin in the present investigation is 1.71% ($\pm$ 0.11), a value more than double that obtained for the rabbit. The same Data book gives the ash content for fat-free human skin as ranging between 1.4 - 2.6% (dry weight basis). If this range of values was based on non-fat-free figures then a higher range of values would have been obtained depending on the quantity of fat present in the human skins investigated. On dry weight basis the ash content value obtained for the goat skin in this experiment has a range of 3.53 - 6.45% and mean of 4.68 $\pm$ 0.32%.

The Organic matter present in the goat skin as obtained from this experiment has a range of 30.26 - 41.49% (wet weight basis) and 93.55 - 96.63% (dry weight basis) with respective wet and dry weight means of 34.82% and 95.32% Sarkar (1964) in his book, "Theory and practice of Leather Manufacture" records the organic matter percentage composition of hides and skins in terms of the protein and fat content as 33% (Proteins) and 2 - 10% (fat - for goat skins). These figures are comparable to those obtained in the present investigation.

5.5.0 <u>The Mineral element Composition of the Goat Skin</u>

From results obtained from the present experiment an ash weight of 1.71 g obtained from 100 g of goat skin gave a total of 0.45 g of the mineral elements investigated (Table 4.11)

When these figures are compared with those obtained by other workers from similar analyses done on steer, cow and bull skins (hides), some similarities and differences in mineral element composition stand out clearly. An interesting fact is the case of sodium and Potassium ions. Carruthers and Suntzoff (1943) working on human and mouse skins found that the predominant cation was potassium and that the sodium content of these skins was half the potassium value. From tables of

published values of mineral element composition of animal bodies by widdowson (1950), and other workers (Spector (ed) 1956) new born mammals (at birth in man, pig and laboratory animals studied) have much larger amounts of sodium than potassium but according to these workers the condition reverses as the animals grow up into adults. From the findings of these seperate workers it is logical to conclude that at different levels of maturity of these mammals the Potassium - sodium ratio in the various tissues of the body will vary. Interestingly the result of the present experiment shows that the skin of the Nigerian Guinea Savannah goats have sodium as the predorminant cation while potassium (if mean values of the mineral ions are considered - see table 4.1[illegible]) is about half the sodium value. The sodium ion value has a wider range than the potassium ion, showing a wider variability than the potassium cation in the goat skin.

Mclaughlin and Theis (1924) who did the earliest work on mineral constituents of the skin used steer, cow and bull skins for their investigations. They reported on differences in mineral constituent of the skin and showed that age had some influence on the mineral content of the skin. The work of several other investigators on the Mineral constituents of skin - mainly man and some laboratory animals - were reviewed by

Rothman (1954) in "Physology and Biochemistry of Skin". Typical figures drawn from the recorded values in his review are reproduced in Table compared with values obtained from the present experiment (see Table 5.3). The value range for potassium is higher than that obtained in the present experiment. The range of values recorded for sodium is approximately the same as that obtained in the present experiment. The same thing can be said of calcium and magnesium while values of copper, zinc and iron are higher for the goat skins than those recorded by Rothman (1954).

According to underwood (1966) an adult 70-kg man is estimated to have 1.4-2.3g zinc in the whole body. Pories, et al (1967) estimated that 20% of the total zinc content in the body of an adult man resides in the skin. This will mean that 0.28-0.46g zinc is to be found in the entire skin of an adult man. An adult goat of the Guinea Savannah vegetative zone of Northern Nigeria, from the present experimental work, has been found to have 0.17 - 0.49 g of zinc in the entire skin (see table 4.12). This range is very close to the range of values of zinc content in man's skin.

The value range obtained for fat-free skin of adult man based on the dry weight of the skin is given as 3-19mg Copper/100g skin (Spector, 1956). This is the same as 0.003 - 0.019 g Copper /100g skin. On wet basis this figure will be quite lower

The range of values for copper obtained in the present work for goat skin is given as 0.0014 - 0.0118 g copper/100g skin (wet weight). Fat-free skin of man has a moisture content of between 70-75% (Spector 1956). Thus, the copper value (on wet weight basis) will now become 0.003-0.019g copper/170 or 175g skin. Using 70% as the percentage water content of the human skin the range of values for copper content of the human skin will then be 0.0018 - 0.011 g copper/100g skin (wet weight). This range of values for copper in human skin will be lower if the calculations were based on non-fat-free skin. Since the values obtained for the goat skin is nearly the same range as that calculated for the fat-free human skin, it follows that for the non-fat-free man's skin, the copper content is lower than the copper content of non-fat-free goat skin.

Matrone (1962) reported that there is marked reciprocal zinc - copper antagonism in the animal body so that the increase in the quantity of one results in reduction in the activity of the other. This will mean that there is a ratio for optimum activity existing for these metal ions (zinc and copper) in an animal. But whether such a ratio exists for the skin, as computed for the goat skin in the present work, needs to be investigated. From our results the Zinc: Copper ratio was

computed as shown below :-

$$\frac{\text{Zinc}}{\text{Copper}} = \frac{0.0197}{0.0068}$$

$$= \frac{0.020}{0.007}$$

$$= \frac{3}{1}$$

Thus, our results indicate that the Zinc : Copper ratio is 3 : 1 in the Zaria goat skin.

Values obtained from the present work indicate that cobalt and nickel are present in higher concentrations in the Zaria goat skin than copper. The ratio of nickel to cobalt in the goat skin is approximately 2:1 as computed below :-

$$\frac{\text{Nickel}}{\text{Cobalt}} = \frac{0.0283}{0.0127}$$

$$= \frac{0.028}{0.013}$$

$$= \frac{2}{1}$$ to the nearest whole number

The nickel ion (from the present study) is also higher than Zinc and suprisingly slightly higher than Magnesium ion levels in the goat skin. It is known than Nickel occurs in low concentrations in all animal tissues and fluids that have been examined by sufficiently sensitive and reliable analytical methods (Underwood, 1977), neither does the ion accumulate particularly in any known tissue or organ of the animal body (Underwood, 1977). Nickel levels of washed fat-free hair of 25 women and 79 men were found to average 3.96 $\pm$ 1.055 and

0.97 ± 0.147 ug/g Nickel respectively (Schroeder and Nason, 1969). This concentration of Nickel in grams per 100g hair will be 0.0396 ± 0.0106 and 0.0097 ± 0.0015 g/100g hair respectively for the women and men. The level of Nickel obtained for the goat skin in the present study is a mean of 0.028 ± 0.009 g/100g skin and this average stands between the value obtained for the women and the value obtained for men by schroeder and Nason (1969).

Though Magnesium is a macroelement, being required in relatively large amounts as compared to the trace elements, yet it's level in the goat skin is slightly,lower than the Nickel level in the same skin (Table 5.2). Todd, (1969) states that 70% of the total body Magnesium is present in the skeleton. The other 30% is distributed in tissues and fluids where it performs different functions.

It is known that most of the mineral elements present in the hair are lost to the animal as these cannot be utilized again in the metabolic processes of the body. Perhaps the hair of the skin may serve as a'dumping ground' for unwanted elements and if so it will be expected that the hair will contain higher levels of the unwanted or excess mineral elements than these elements more constantly needed in the normal processes in the animal body.

TABLE 5.2

Mean values of the mineral elements (in grams) present in the Guinea Savannah goat skin.

Element	Mean Ionic Content (g)	Range (g)
Calcium	0.0516	0.03 - 0.09
Sodium	0.1516	0.07 - 0.30
Potassium	0.0884	0.03 - 0.22
Magnesium	0.0200	0.01 - 0.04
Zinc	0.0197	0.01 - 0.03
Iron	0.0713	0.02 - 0.12
Copper	0.0068	0.001- 0.012
Nickel	0.0283	0.01 - 0.043
Cobalt	0.0127	0.006- 0.02

TABLE 5.3

Comparison of values for Mineral ion content of the Guinea Savannah Goat Skin with typical values obtained by various workers and reviewed by Rothman (1954)

Mineral ion	Percentage Value in Guinea Savannah Goat skin	Typical values for the skin in general (Rothman, 1954)
Potassium	0.03 - 0.22	0.322 - 0.558
Sodium	0.07 - 0.30	0.122 - 0.247
Calcium	0.03 - 0.09	0.015 - 0.065
Magnesium	0.01 - 0.04	0.018 - 0.034
Copper	0.001- 0.012	0.00056
Zinc	0.005- 0.03	0.0024
Iron	0.02 - 0.12	0.0010

5.6.0 Distribution of the Mineral elements in the goat skin

From the results of the present investigation the fact clearly emerges that the mineral elements are not evenly distributed throughout the skin. A glance at Table 4.13 clearly reveals this fact. When measured in terms of weight of the mineral elements present in 10 grams of skin taken from the different regions of the goat skin, it is seen that the butt region has the greatest amount of mineral elements (0.0125 g/10g skin) while the belly region has the least (0.0026 g/10g skin). Variations in concentration (or quantity) exist in the animal skin. This is expected to be so since there are structural variations throughout the skin. This finding is confirmed by the work of Tancous (1955) on steer and cow hide from which it was shown that there is variation in the chemical composition of hides and skins from region to region.

Thus, figures given in the Monograph -" Indian Hides and Skins - Histological characteristics" (Nayudama, 1963), for the hair density of the skin show that the Butt has the highest hair density (9,500 hairs per 6.45 cm^2 of skin), the back-bone has the next highest with a hair density of 9,00 hairs per 6.45 cm^2, the neck has 7,500 hairs per 6.45 cm^2, while the belly has 6,000 hairs per 6.45 cm^2. Infact the mineral content values for the regions whose hair densities are given follows the same order of

magnitude as the hair densities. The butt has a total metal ion content of 0.0125 g/10g skin, the back-bone has 0.0051 g/10g skin, the neck has 0.0032 g/10g skin while the belly has 0.0026 g/10g skin.

Since hair contains some of the metal ions of the skin, then hair length is also an important determining factor in the distribution of mineral elements in the skin. The longer the hair the more mineral elements are to be expected. However, evidence from literature shows that some elements are more abundant in the hair than in the skin proper eg. Zinc (Follis, 1958) while some are relatively more abundant in the skin proper than in the hair eg. Magnesium and calcium (Tancous, 1955).

Another important factor that affects the distribution of the mineral elements in the skin is the protein structure. It is known that copper ions are involved in the cross-linkages of the collagen fibres (Rucker, et al, 1969) making for increased tear strength of these protein structures. It is expected therefore that copper ions will be more abundant in that part of the skin that has greater tear strength than the part that has lower tear strength, all other factors being equal.

A fourth factor in the distribution of mineral elements in the goat skin is the type(s)

of associated mineral elements present. Since, for instance, it is known that the presence of Zinc ions modifies the activity of copper ions and vice versa (Hill and Matrone, 1962) then the presence of one will modify the quantity of the other taken up in the skin.

5.7.0 <u>The Inter-relationships between the metal ions; and between the metal ions and other measures.</u>

Results from the present investigation have so far revealed that the mineral ion content of the skin has a measure of relationship with the total length of the animal. As the total length increases the mineral ion content (though not necessarily the concentration) also increases. This should be so since increase in length implies increase in skin size and therefore increase in the mineral ion content of the skin.

It was also found that the zinc ion level in the skin is negatively correlated with the moisture content of the skin. The level of correlation is quite low but neverthless an interesting fact emerges - the fact that such correlation corroborates the findings of Hsu and Anthony (1974) that "the water content of the skin of zinc - deficient rat was significantly higher than that of zinc - supplemented pair-fed controls".

The coefficients of correlation between copper and all other mineral elements of the skin are

negative except in the case of sodium ions where the coefficient of correlation is positive. The correlation between zinc and copper is negative and the relationship between the two ions is such that as one increases the other decreases. This relationship conforms with the findings of Hill and Matrone (1962) on zinc and copper ions. They reported that there is marked reciprocal zinc -copper antagonism in the animal body. This finding seems to hold true for the fresh goat skin though more work needs to be done here in order to verify the statement.

The distribution map of the mineral elements in the skin reveals that most of the elements are found in the highest abundance in the extremities of the skin. The skin covering the dorso-posterior parts of the goat contains more cobalt than that portion covering the anteroventral parts. Iron seems to be most evenly distributed having only slight variations at the different regions. Nickel levels are low in the anterior parts and high in the posterior. Copper varies throughout the skin. It's levels in the neck and mammary area are approximately the same. The chest and butt regions (including the front-butt) are only slightly different in levels between them. There are marked variations in level between other regions. The shank skins and tail have nearly the same levels of magnesium and the levels here are higher than those

of all the other regions. The other regions have uniform distribution of the Magnesium ions. Zinc levels in the back-bone and shanks are higher than in the other regions while the mammary area and the butts have the lowest levels of zinc. Calcium levels in the mammary area, posterior shank and tail were found to be relatively higher than in the other regions where only slight variations exist. Sodium levels in the shanks and tail differ from the level of sodium in the other parts which parts again show some evenness in distribution of the ion. The level of Potassium ions is relatively low in the lateral and ventral parts of the skin of the goat.

5.8.0 Evaluation of the nutritional quality of the goat skin in terms of the mineral element composition.

If the entire goat skin of 1.40 kg wet weight is dried to eliminate the moisture contained in it the weight of the dried skin will come down to 0.896 kg.

A dry goat skin weighing 896g when cut up and ground to powder will contain a total mineral element weight of 6.22g. This weight of mineral elements will be made up of 0.72 g Calcium, 2.12 g sodium, 1.23 g Potassium, 0.28 g Magnesium, 0.27 g Zinc, 0.97 g Iron, 0.09 g Copper, 0.38 g Nickel and 0.17 g Cobalt. If 20 gm weight of the ground skin is taken, then this will contain

0.016 g Calcium, 0.047 g Sodium, 0.028 Potassium, 0.006 g Magnesium, 0.006 g Zinc, 0.022 g Iron, 0.002 g Copper, 0,009 g Nickel and 0.004 g Cobalt. Suppose this 20 gm. weight of dry skin containing the above amounts of mineral elements is added to the daily ration of an animal that feeds on 80 g of feed stuff, then the total daily ration of the animal will weigh 100g. If we suppose further that the original 80 g ration of the animal contained no mineral element, then the addition of the ground goat skin will supply the mineral elements listed above. The concentration of the mineral elements in the feed stuff in p.p.m. (parts per million) will then be as follows ;-

Calcium	-	160 ppm
Sodium	-	470 ppm
Potassium	-	280 ppm
Magnesium	-	60 ppm
Zinc	-	60 ppm
Iron	-	220 ppm
Copper	-	20 ppm
Nickel	-	90 ppm
Cobalt	-	40 ppm

According to Miller and Miller, (1960) the zinc requirement for normal growth in calves lies between 3 and 46 ppm. Therefore, a feed staff of 100g containing 20g dried ground skin will be more than sufficient to provide the zinc necessary for normal growth in the calf since such feed will

contain 60 ppm zinc. Mills and Murray (1960) showed that 4 - 6ppm copper, on dry basis, with relatively low molybdenum and inorganic sulphate, provides sufficient copper for full requirements of cattle and sheep of British breed and cross-breed. Therefore, a feed meal of 100g containing 20 gm weight ground dried skin will again provide the full nutritional requirements for copper in the British cattle and sheep since, according to our computations above, such a feed stuff will contain 20 ppm copper. Necessary adjustments could be made in the feed stuff - dried skin ratio to bring down the copper level in the feed stuff so that toxic dietary levels of the element will not be present in the feed.

Studies by Matrone et al (1957) showed that the minimum iron requirement for growth in calves is not more than 30 mg/day. This quantity of iron can be obtained from 27.7 g ground dried goat skin.

Reports from New Zealand and Australia show that 0.07 ppm Cobalt in the dry diet is quite adequate for sheep and cattle and this figure has been accepted as the minimum optimal requirement for these animals while recent evidence indicates that the amount required by lambs is at least 0.10 ppm (Andrews, et al, 1958). This amount of Cobalt ions is readily obtainable from 2 gm weight

ground dried goat skin.

Mitchell (1947) from his work on chick and calf gave the normal Magnesium requirement for the two animals as 0.04% and 0.07% of the dry diet respectively. Miller et al (1965) placed that for baby pigs fed on a purified diet at 0.0325% (or 325 ppm). Blaxter and Mc Gill (1956) reported that pastures or rations containing not less than 0.07% (Magnesium) of the dry ration sustained sheep and cattle for normal growth while about 0.1% Magnesium was adequate for the minimum needs of lactating ewes and Cows. In this case ground dried goat skin could be used to supplement the magnesium ions present in the feed stuff of the animal.

The Committee on Animal Nutrition of the National Academy of Sciences, according to their published report of 1945 on the nutritional requirements of sheep, has recommended that forage (or feed stuff) containing 0.24 to 0.32 percent calcium is considered adequate for sheep (Pope 1945). Meyer, et al (1950) fed weaner pigs on purified diets extremely low in sodium, potassium and chlorine and from their work found that the dry diet for these animals should contain not less than 0.08 to 0.10% sodium, 0.23 to 0.28% potassium and 0.12 to 0.13% chlorine. It is clear then from these findings that ground dried goat skin can be

used as a food supplement to supply some of the calcium, sodium and potassium needed by animals.

Man does not usually consume the hair of the goat skin. In Nigeria the practice before consuming the goat meat is to slaughter the animal, drain the blood and burn off the hair, and then cook, fry or roast the entire animal carcass or parts thereof before consumption without flaying the skin. In the Moslem North of Nigeria the practice is to flay the goat after slaughter so that the skin is not usually eaten . Cow skins (Hides) however are normally boiled, stewed and eaten here as a special delicacy. In removing the hair of the animal much of the mineral ions present is lost but a good quantity of the elements is still consumed when the skin proper is eaten.

5.9.0.<u>The Hair of Goat Skins as Feed Supplement</u>.

Some goats such as the Angoran, Soviet Mohair and Philippine goats, are bred mainly for their hair or wool (Devendra and Burns, 1970). The hair or wool obtained from these goats is normally utilized in the Fabrics Industries for the manufacture of clothing, carpets, Upholstery, etc. The hair or wool thus becomes a source of economic earning.

Large quantities of the hair of animal skins are however wasted, especially in the Leather Industries during the Beam house operations when the skins are unhaired before being processed into leather. The hair removed from the skins is often unwanted and

discarded as an industrial waste thus, not only being wasted but also increasing the disposal problem and concomitant health hazard that these industrial wastes often constitute. Hides and skins shavings consisting of the epidermal layers are usually lost with the skins as these are not normally required during the manufacture of ordinary leather (without hair). Large quantities of human hair are also wasted in barbers shops after hair shaves. These hairs are biological materials that contain valuable materials that can be utilized in the face of the present world food and economic crises for reducing human suffering by conversion into usable items.

Though hair has little or no food value in terms of it's protein, fat, and carbohydrate composition, yet it contains appreciable quantities of very important trace elements such as zinc (Tancous, 1955), Copper (Sandell and Onishi, 1944), Nickel (Schroeder and Nason, 1969), iron (Underwood, 1977), as also shown from the results of the present studies. The hair primarily consists of compactly cemented keratinized cells produced by follicles (Montagna and Parakkal, 1974). The shaft of the hair consists of an outer layer of one cell thick cuticle that is enveloped by a thin layer of lipid and carbohydrate; a middle medulla of one or two cell layers thick consisting of medullary proteins which on analysis reveals the presence of a low concentration of

cystine and a high concentration of glutamic acid and glutamine, and a small amount of citrulline (Black-burn, 1948). (The medullary protcins, according to Blackburn (1948), are highly resistant to chemical and enzymic treatment but can be solubilized after reduction or oxidation); an inner cortex that makes up 85 - 90% of wool and hair, consisting of elongated cells that contain keratinous proteins which, according to Crowther, et al (1965), resist action by proteolytic enzymes, and are insoluble unless after severing the disulfide bonds either by reduction to obtain proteins called kerateines or by oxidation to obtain proteins called keratoses (Goddard and Michealis, 1935). Gillespie (1960) writes that in addition to the above proteins, crude preparations of low - sulphur proteins obtained from reduced wool contain small amounts of a protein rich in glycine and tyrosine and that this protein accounts for 2 to 3% of the wool fibre and is extremely heterogenous. Citrulline, which is a derivative of arginine, is present in the filaments of the inner root of the sheath of the hair (Montagna and Parakkal, 1974).

From the foregoing, it is clear that the food value of the hair in terms of the proteins, fats, and carbohydrates that can be digested and assimilated through the normal digestive process in man and other animals is almost nil. However, by the reduction and oxidation processes mentioned, it

is possible to extract these nutrient materials and compound them into concentrates that may be used as food supplements either for man or his domestic animals, in addition to the essential mineral elements which the hair contains. It is possible too to extract some quantities of the mineral elements by a simple process of incineration in an enclosed container and extraction with water. This water extract can be added to the drinking water of livestock to supply the necessary mineral elements to prevent mineral deficiency diseases in the animals.

In trying to combat the present food and economic crises of the world today efforts, through the co-ordinated action of the world Food Committee (1974) and the Food and Agricultural Organisation of the United Nation, are now geared towards higher food production, even from Industrial wastes (Birch, et a l, 1976). To this end, scientists are working towards devising new processes for conversion of hitherto unused wastes into food and other useful materials. Already carbohydrates (sugars) are being manufactured from waste papers (Birch, et al, 1976).

S U M M A R Y

1. An average Guinea Savannah goat in Nigeria has a live weight of 22.26 kg, a total length (from snout to tip of tail) of 1.19 m, a chest girth of 0.23 m and a fresh skin weight of 1.47 kg.

2. The body weight of the goat increases as the total length increses.

3. The weight of the skin increasesas the body weight increases.

4. A measure of correlation exists between the wet skin weight and total length; between the live weight of body and horn length; and between the average horn length and total length of the animal: as one increases the other also increases.

5. The moisture content of the average Guinea Savannah goat skin is 63.47% The moisture content varies from one part of each bilateral half to another part of the same half.

6. The total ash of the wet skin is 1.71% and on dry weight basis the mean ash content is 4.68%. The organic matter content on wet basis lies between 30.26% and 41.49% with a mean of 34.82% while on dry basis it lies between 93.55 and 96.47% with a mean of 95.32%.

7. The average goat skin in the Guinea Savannah region of Nigeria has a total mineral ion content of :-

$(0.00278 + \frac{M}{2236})\%$ of the weight of the live goat, where M is the total weight(g) of all other mineral ions present in the skin (those ions not investigated in the present study). All the metal ions of the skin investigated put together, make up 0.00278% of the total live weight of the goat. The individual percentages are as shown below :

Calcium	=	0.00032 %
Sodium	=	0.00095 %
Potassium	=	0.00055 %
Magnesium	=	0.00013 %
Zinc	=	0.00012 %
Iron	=	0.00043 %
Copper	=	0.00004 %
Nickel	=	0.00017 %
Cobalt	=	0.00008 %

8. Zinc is negatively correlated with the moisture content and with the copper level of the goat skin. As water content increases, the zinc level decreases and vice versa. As the zinc level increases the copper level decreases and vice versa. Other metal ions investigated relate positively to one another.

9. The mineral elements investigated are not evenly distributed throughout the skin. Some elements are more abundant in one part of a bilateral half than in another part of the same half. The same may be said of the moisture, ash and organic contents of the skin.

10. In terms of mineral elements the Guinea Savannah goat skin can serve as food supplement to supply some of the essential minerals necessary for the healthy development of animals.

C O N C L U S I O N

It has hitherto been argued that hides and skins are of little or no nutritional value and would be more profitably used in the leather Industry for the manufacture of leather goods since, it is claimed, that man's digestive system is not equiped to handle the collagen component of the skin and make it's amino acids available for use to man. Nothing however is said of this material in terms of it's mineral element content as means of supplementing the nutritional requirement of the element either in man's food or in the food of animals other than man. It is the conviction of the present investigator that the goat skin and particularly the hair, might prove an important source of the mineral elements for use in the feed stuff of domestic animals.

Some goat skins eg. the Sokoto red goat skins, have been found to produce better quality leathers than other goat skins in Nigeria. The factors responsible for this have not yet been elucidated. Perhaps the mineral element composition of the goat skins might play an important part in the skins quality as lack of these element or their deficiency in the animal body have conclusively been associated with both skin diseases and diseases of the body of the animal. Copper ions, for instance, are important in the cross - linkages of the collagen fibres. It may turn out to be that skins with greater shear strength have a higher level of copper ions than those of weaker shear strength under normal health conditions of the animals. Further investigation is pertinent and the present work forms a basis .

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Serial no. of each goat skin	Region of goat skin									
	Neck	Chest	Anterior Shank	Anterior belly area	Mammary area	Posterior shank	Butt	Back-bone	Front Butt	Tail
1.	0.914	0.991	0.883	0.725	0.839	1.033	0.982	0.963	0.810	1.282
2.	0.742	0.839	0.795	1.021	0.824	0.766	0.636	0.839	1.172	0.868
3.	0.751	1.006	0.562	0.724	1.402	0.916	0.667	0.865	1.262	1.156
4.	0.687	0.638	0.622	0.735	0.699	0.660	0.609	0.759	0.741	0.750
5.	0.628	0.694	0.691	0.656	0.582	0.694	0.688	0.680	0.776	0.750
6.	0.756	0.770	0.442	0.512	0.703	0.746	0.483	0.940	1.249	0.924
7.	0.985	1.186	1.111	1.376	1.097	1.059	0.630	1.492	1.189	1.453
8.	0.694	0.685	0.754	0.667	0.420	0.668	0.554	0.519	0.548	0.982
9.	0.833	0.717	0.609	0.694	0.966	0.672	0.690	0.790	0.723	0.834
10.	0.710	0.610	0.658	0.547	0.659	0.760	0.524	0.775	0.764	0.951

APPENDIX I

Table 4.4a

Weight of Fresh Skin Samples punched out of various regions of each goat skin and used for all analyses.

Serial no. of each goat skin	Region of goat skin									
	Neck	Chest	Anterior shank	Anterior belly area	Mammary area	Posterior shank	Butt	Back-bone	Front Butt	Tail
1.	0.438	0.395	0.355	0.291	0.292	0.335	0.359	0.365	0.393	0.578
2.	0.281	0.338	0.317	0.327	0.260	0.318	0.288	0.358	0.499	0.365
3.	0.308	0.416	0.305	0.283	0.489	0.380	0.339	0.434	0.486	0.613
4.	0.194	0.227	0.172	0.175	0.228	0.181	0.183	0.267	0.269	0.378
5.	0.222	0.249	0.259	0.158	0.209	0.215	0.198	0.356	0.277	0.277
6.	0.259	0.272	0.177	0.151	0.184	0.247	0.157	0.276	0.432	0.296
7.	0.327	0.364	0.405	0.472	0.350	0.410	0.249	0.599	0.436	0.604
8.	0.267	0.248	0.262	0.193	0.198	0.220	0.122	0.277	0.255	0.437
9.	0.290	0.262	0.215	0.243	0.257	0.210	0.225	0.262	0.256	0.319
10.	0.246	0.222	0.272	0.184	0.200	0.254	0.180	0.277	0.267	0.386

APPENDIX II

Table 4.4b

Final weights obtained when the original fresh skin samples punched out from the various goat skin regions (Appendix I) were oven dried.

Serial no. of each goat skin	Region of goat Skin									
	Neck	Chest	Anterior shank	Anterior belly area	Mammary area	Posterior shank	Butt	Back-bone	Front Butt	Tail
1.	0.010	0.012	0.015	0.005	0.012	0.018	0.015	0.011	0.022	0.023
2.	0.006	0.007	0.018	0.014	0.019	0.021	0.009	0.024	0.025	0.016
3.	0.014	0.013	0.009	0.006	0.033	0.008	0.010	0.021	0.023	0.034
4.	0.009	0.007	0.006	0.008	0.002	0.006	0.010	0.018	0.008	0.021
5.	0.011	0.013	0.010	0.015	0.012	0.010	0.011	0.034	0.019	0.021
6.	0.015	0.020	0.009	0.001	0.005	0.020	0.007	0.024	0.027	0.024
7.	0.006	0.011	0.026	0.007	0.017	0.020	0.007	0.017	0.016	0.022
8.	0.012	0.007	0.012	0.014	0.015	0.014	0.004	0.013	0.014	0.027
9.	0.006	0.007	0.021	0.011		0.011	0.010	0.009	0.009	0.007
10.	0.010	0.007	0.017	0.004		0.017	0.011	0.009	0.009	0.014

APPENDIX III

Table 4.4c

Ash weight of the dried skin samples from the various goat skin regions (Appendix II).

Specimen no.	Mean Weights of ten samples fresh skin (g)	Standard Error	Mean Weights of ten samples Dried Skins (g)	Standard Error	Mean Weights of ten samples ash (g)	Standard Error
1.	0.9422	±0.0480	0.3800	±0.0262	0.0143	±0.0018
2.	0.8502	±0.0470	0.3350	±0.0210	0.0159	±0.0022
3.	0.9311	±0.0865	0.4050	±0.0328	0.0171	±0.0032
4.	0.6900	±0.0176	0.2270	±0.0203	0.0095	±0.0018
5.	0.6839	±0.0175	0.2470	±0.0173	0.0156	±0.0024
6.	0.7525	±0.0775	0.2450	±0.0267	0.0152	±0.0029
7.	1.1578	±0.0797	0.4220	±0.0346	0.0149	±0.0022
8.	0.6491	±0.0488	0.2460	±0.0257	0.0132	±0.0019
9.	0.7528	±0.0328	0.2540	±0.0106	0.0101	±0.0014
10.	0.6958	±0.0398	0.2490	±0.0190	0.0109	±0.0014

APPENDIX IV

Table 4.4d

Mean weights of skin samples obtained from ten different regions of each goat skin.